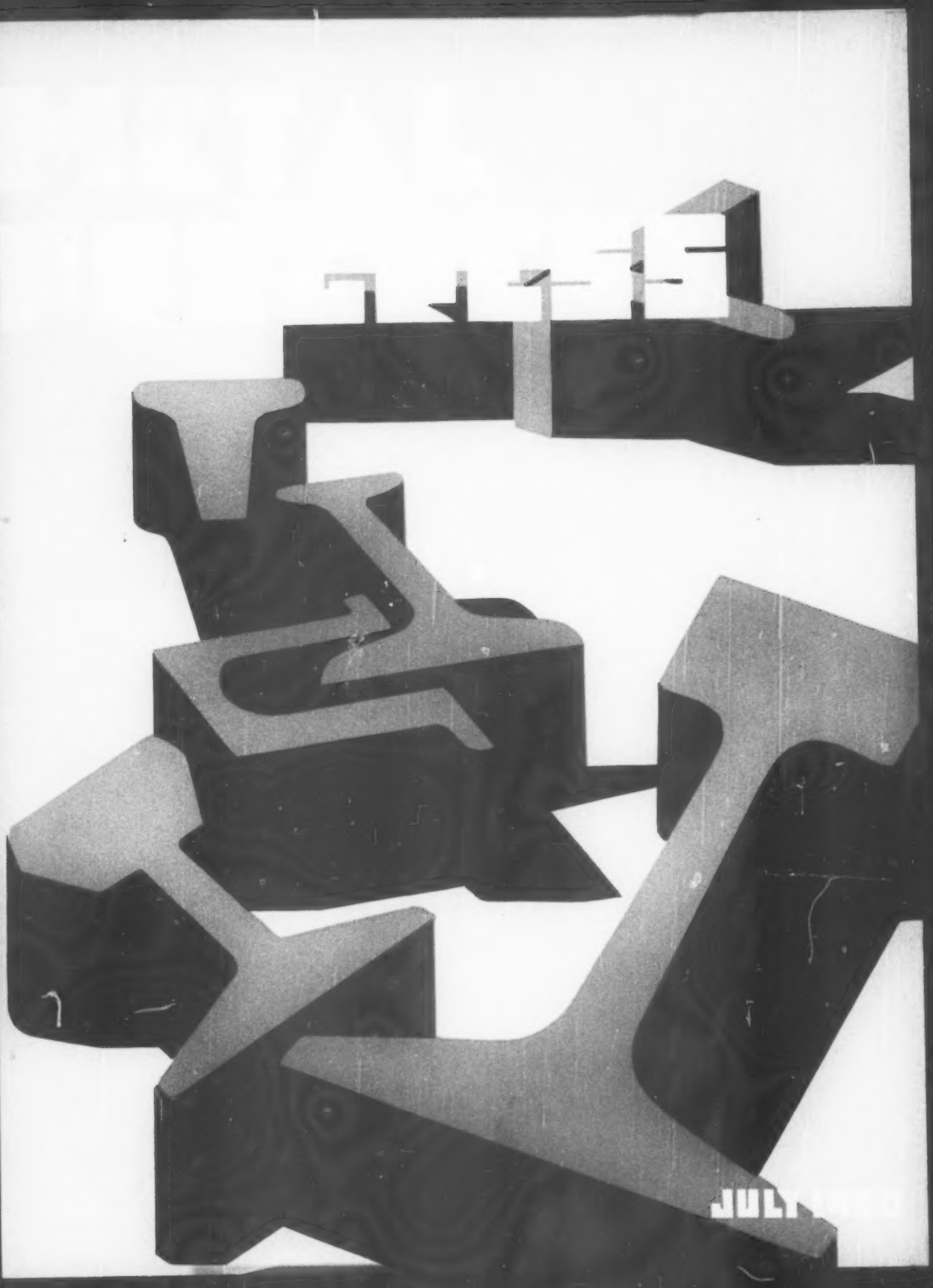
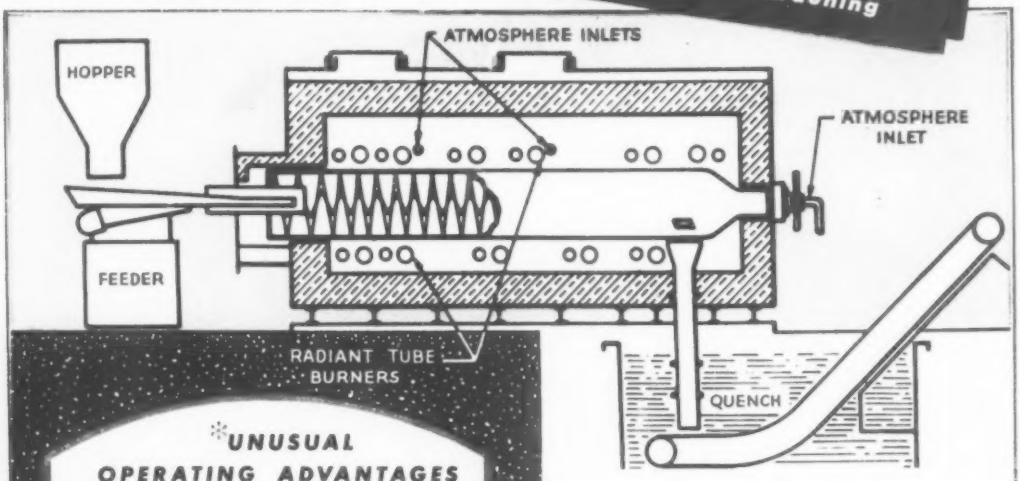


Fully Automatic—High Production

ROTARY RETORT
CONTROLLED ATMOSPHERE FURNACES*

FOR MODERN HEAT TREATMENT INCLUDING:
Gas Carburizing
Dry (gas) Cyaniding
Homogeneous Carburization
and Clean Hardening



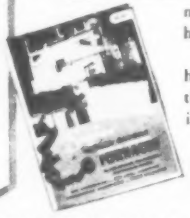
A 'Surface' Rotary Retort Furnace is equipped with one or more cast alloy retorts, each provided with an internal screw thread. The retorts are operated with an oscillating type of motion which is gentle and non-abrasive and accomplishes a forward movement of the metal pieces through the retort.

*UNUSUAL OPERATING ADVANTAGES

1. Improved and uniform contact of metal pieces with the prepared gas atmosphere, as compared with other types of work handling.
2. High thermal efficiency. No trays or fixtures to heat or cool.
3. Fully automatic operation possible . . . minimun of manual handling. Low maintenance costs.
4. Especially adaptable to limited production by control of rotation cycle and/or charging rate.
5. 'Surface' RX Gas Atmosphere Generator supplies atmosphere gas for all modern heat treatments.

● 'Surface' Rotary Retort Furnaces are the first successful units of their kind because a protective atmosphere is utilized within the heating chamber as well as the rotary retort. A positive pressure is maintained within both areas, thereby protecting the metal from outside air contamination during heat treating and quenching.

These units provide unusually high quality heat treatment. Capital investment about 40% that of equivalent pusher-type furnace. Minimum space required for high production.



◀ *Complete details are given in Bulletin SC-147. Write for your copy today.*

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

FOREIGN AFFILIATES:
Stein & Roubaix, Paris — British Furnaces, Ltd., Chesterfield

'Surface' **INDUSTRIAL FURNACES**

FOR: Gas Carburizing and Carbon Restoration (Skin Recovery), Homogeneous Carburization, Clean and Bright Atmosphere Hardening, Bright Gas-Normalizing and Annealing, Dry (Gas) Cyaniding, Bright Super-Fast Gas Quenching, Atmosphere Malleableizing and Atmosphere Forging. Gas Atmosphere Generators.

THIS ISSUE

Fatigue Failure 51

of railroad materials

Rails . . . Joint bars . . . Diesel locomotive wheels . . . Valve rocker arms

Aluminum 56

production at new plant in Texas

Operation of modern reduction cells on power generated with natural gas

Castings 60

improved by graphite molding mix

Chilling mixture with molding properties of sand but higher heat flow

Columbium 63

versus titanium in 18-8 stainless

Direct comparison of Types 347 and 321 . . . Welding and forming characteristics . . . Creep . . . Oxidation . . . Service behavior in aircraft components

Radiography 80-B

of steel with a cobalt-60 source

Modulus 85

of elasticity at high temperatures

Data for six high-temperature alloys

Complete Table of Contents on p. 49

How to GET over 17,000 "AT HOME" welcomes to your advertising message

No mystery! No mirrors! No mirages! Metal Progress is delivered right to the HOMES of over 17,000 out of 21,000 readers every month.

Metal Progress Advertising is *Read* (99% by actual survey). Metal Progress readers are influenced by its Advertising (96% by actual survey). Metal Progress Readers *ACT* upon Metal Progress Advertising (78% by actual survey).

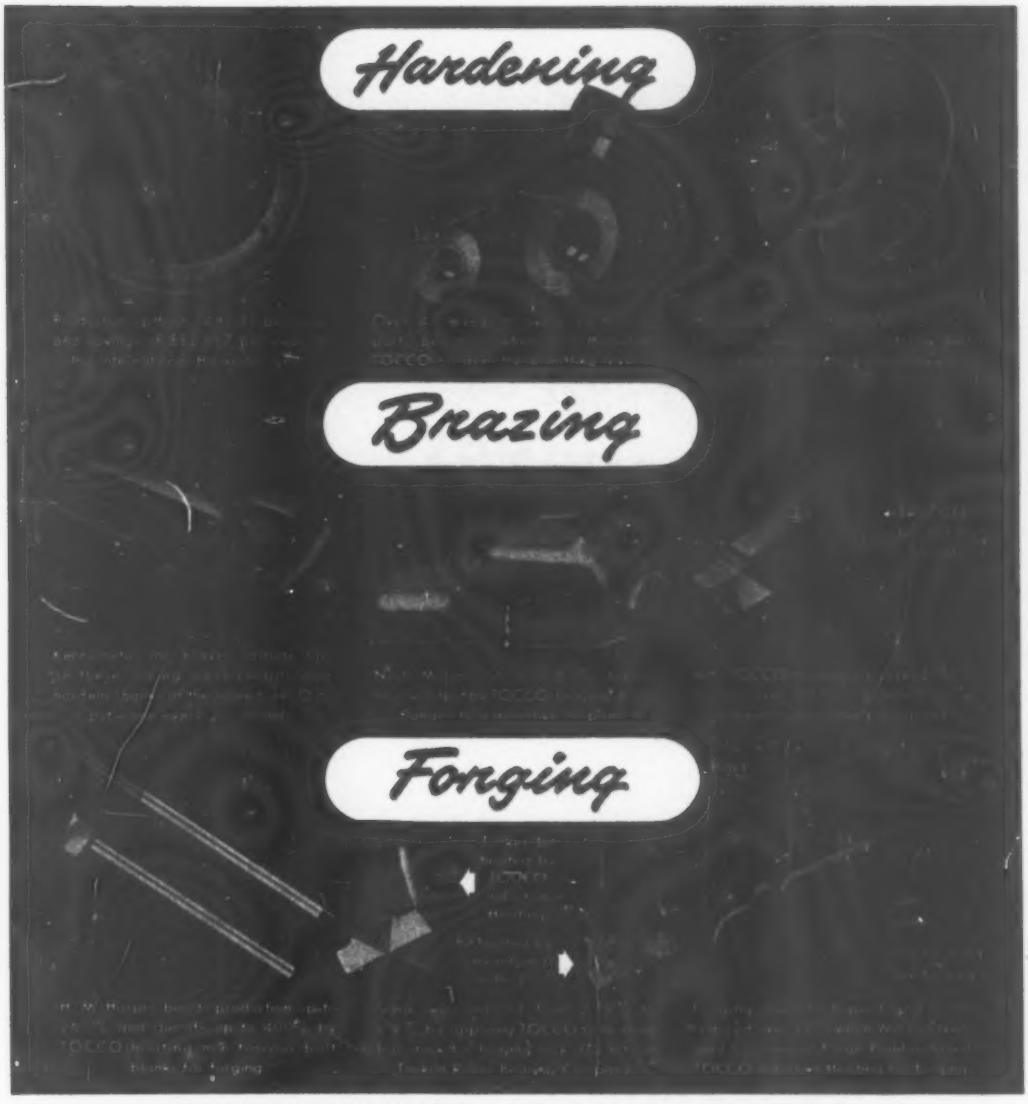
The "At Home" feeling of over 17,000 Metals Engineers makes Metal Progress Advertising easy to *read*, easy to *study*, and easy to *ACT* upon.

No Wonder Metal Progress is Tops!

METAL PROGRESS

7301 EUCLID AVE.

CLEVELAND 3, OHIO



All These Jobs, And Probably Some of Yours, Can Be Done Faster, Better and at Lower Cost with TOCCO® Induction Heating

THE OHIO CRANKSHAFT COMPANY

TOCCO

JUST PUSH A BUTTON

Mail Coupon Today

NEW FREE BULLETIN

THE OHIO CRANKSHAFT CO.
Dept. R-2 Cleveland 1, Ohio

Please send copy of "TOCCO Induction Heating".

Name _____

Position _____

Company _____

Address _____

City _____ Zone ____ State _____

YOU CAN FIGURE ON 2 LABOR SAVINGS *with* "PSC" CARBURIZING FIXTURES

The rack pictured above is a typical example of how The Pressed Steel Co. is helping its customers, in two ways, to cut labor costs.

First, in parts handling. This fixture, with its removable trays, eliminated three complete handlings. The trays get their load of small parts at machine side. Without further handling they are trucked, carburized, quenched and then routed through finishing.

Second, because PSC welded alloy heat-treating equipment weighs 2/3 less than cast equipment, it handles easier and faster; in addition it requires less time to attain pot heat. A recent study of one customer's cycle showed a total saving of 5 hours.

Let our technical staff work with you in devising production savings. As pioneers of light-weight, sheet alloy heat-treating containers and fixtures, we make available to you a wealth of designing and production know-how. Whether you are installing new furnaces or need replacement equipment, let us send you information how PSC welded alloy units cut labor and fuel costs, and shorten heating cycles. We furnish standard or special welded alloy equipment in any size, and in any metal to meet your heat and corrosion requirements. Send blue prints or write as to your needs.

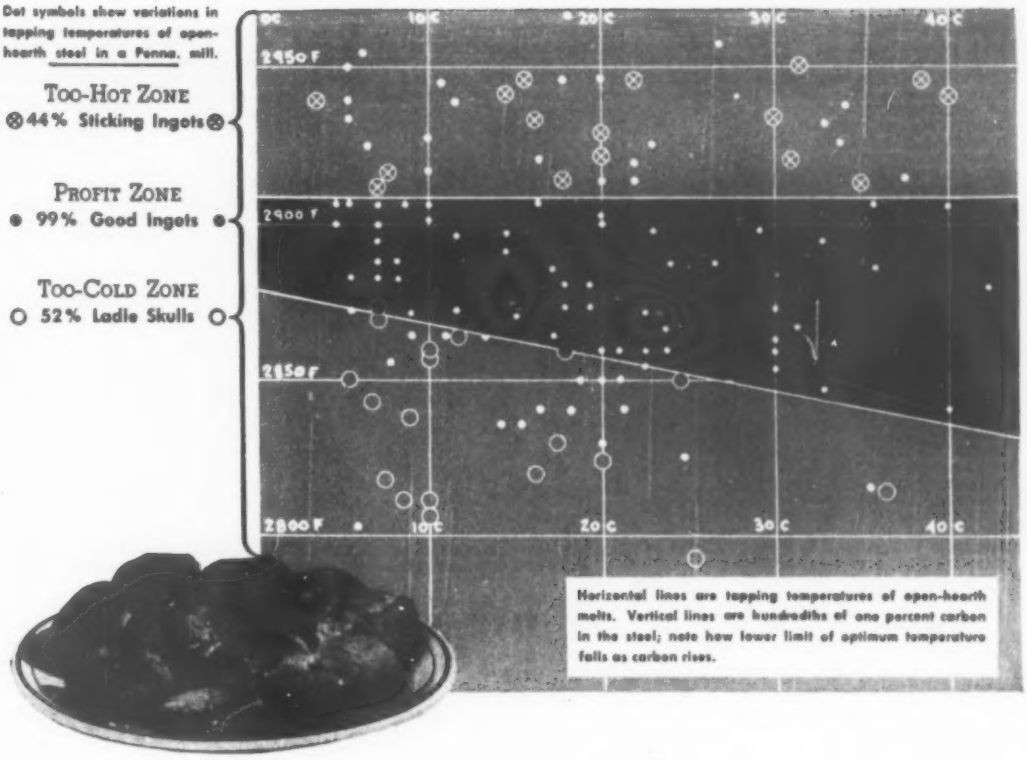
Light-Weight **Heat-Treating Equipment for Every Purpose**

Carburizing and Annealing Boxes	Tumbling Barrels - Tanks
Baskets - Trays - Fixtures	Cyanide and Lead Pots
Muffles - Retorts - Racks	Thermocouple Protection Tubes
Annealing Covers and Tubes	Radiant Furnace Tubes and Parts
Pickling Equipment	Heat, Corrosion Resistant Tubing

THE PRESSED STEEL COMPANY
of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

☆ ☆ ☆ OFFICES IN PRINCIPAL CITIES ☆ ☆ ☆


Dot symbols show variations in tapping temperatures of open-hearth steel in a Penna. mill.
TOO-HOT ZONE
⊗ 44% Sticking Ingots ⊗
PROFIT ZONE
● 99% Good Ingots ●
TOO-COLD ZONE
○ 52% Ladle Skulls ○
0C
10C
20C
30C
40C
2950 F
2900 F
2850 F
2800 F
Horizontal lines are tapping temperatures of open-hearth melts. Vertical lines are hundredths of one percent carbon in the steel; note how lower limit of optimum temperature falls as carbon rises.

Fewer "Bride's Biscuits" from the Open Hearth

As every open-hearth man knows, molten steel is not unlike a bride's biscuit—it sticks to things. When tapped too hot, it sticks to ingot molds and stools; when too cold, some of the melt never gets to the mold, but sticks in the ladle as a cup-shaped "skull." But—these troubles with steel, like troubles with biscuits, yield to careful, persevering, intelligent methods.

In the case of steel, these methods now include measurements of steel temperature before it leaves the open-hearth furnace, in order to hit the correct tap temperature. And today's perfected model of the Immersion Rayotube is just the instrument for these measurements. Recent Rayotube improvements permit it to be plunged as often as desired right into the liquid steel, as a help in saving time, labor and fuel, while increasing the yield of each furnace melt.

Use Immersion Rayotube Often!

First helpers use the perfected Immersion Rayotube several times while working the heat. They check temperatures both before and after adding ore or oxygen . . . when adding alloy materials . . . when the bath is sluggish, as well as when it is finishing off satisfactorily . . . and always just before blocking or tapping. Using the instrument frequently makes it much easier to bring the melt to correct temperature just at the time all other metallurgical specifications have been fitted together to create the desired steel.

Maintenance Is Lowest

No other way of measuring bath temperature offers such a useful combination of dependable results and freedom from special maintenance after each reading . . . Why not let an L&N engineer supply the facts? Just write us at 4927 Stenton Ave., Philadelphia 44, Pa.

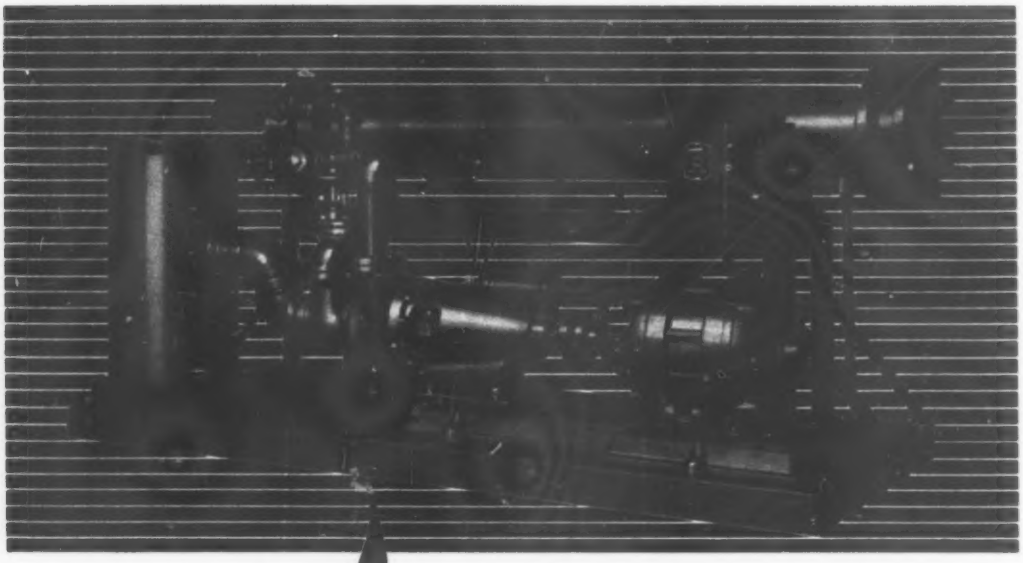
Acknowledgement is made to Clark and Feigenbaum of Jones & Laughlin Steel Co., in their AIMME Technical Paper 2031, for the above chart; but its use does not imply their endorsement of L&N products.

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

LEEDS & NORTHRUP CO.

Jrl. Ad. NS3-338-643(1)

Metal Progress is published and copyrighted, 1950, by American Society for Metals, 7301 Euclid Avenue, Cleveland, Ohio. Issued monthly; subscriptions $7.50 a year. Entered as second-class matter Feb. 7, 1921, at the post office at Cleveland, Ohio, under the act of March 3, 1879



EVERY DROP OF OIL AT THE *Right Temperature* THROUGHOUT THE QUENCH!

Why permit old-fashioned quenching methods to eat up a substantial portion of your profits? By installing a B & G *Hydro-Flo* Oil Cooler, you can eliminate the losses caused by excessive rejects—make an "inside profit" by cutting operating costs.

The "SC" Series *Hydro-Flo* Oil Cooler combines Cooler, Motor, Pump, Strainer and all controls in a single, integrated unit. Completely automatic, it keeps oil temperature at the desired degree through all stages of the quench. You are assured of *uniform quality* in your product because of *uniform quenching conditions!*

Send for combined Catalog and Simplified Selection Manual.

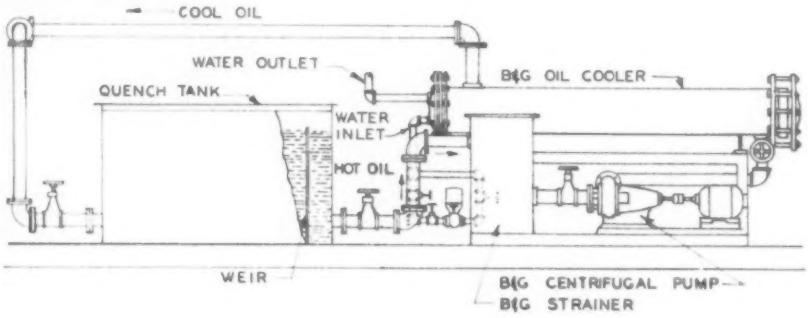


Diagram shows an instantaneous type of B & G Oil Cooler installation, suitable for continuous quenching. The oil in the quench tank and system is cooled at a rate equal to the per minute heat load without need for supplemental oil storage.

Hydro-Flo OIL QUENCHING SYSTEMS

BELL & GOSSETT COMPANY

Dept. BP-16, MORTON GROVE, ILLINOIS

*Reg. U.S. Pat. Off.

WHAT THE BELL TOLD—

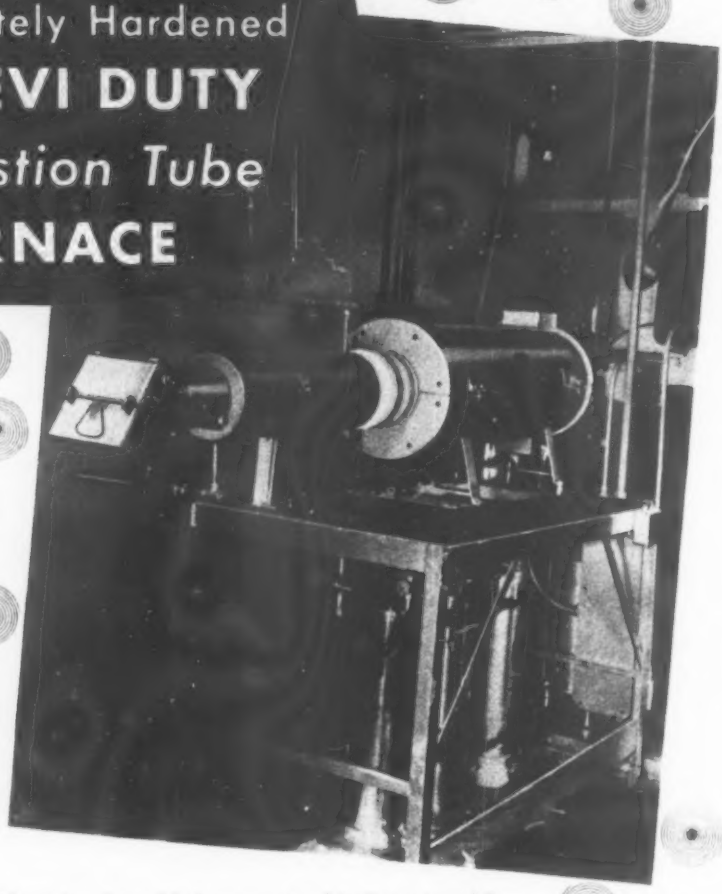
When the Liberty Bell announced our freedom 174 years ago this month, it told all the world a story of mankind's progress. The ancient bell is cracked and silent now, but the freedom it signaled is as vital as ever. It is ours to cherish and protect.

The Wisconsin Steel organization believes that progress and competition are marks of freedom. They make freedom live. Unhampered by tyranny and oppression, we have moved steadily forward, constantly improving our products to compete with other steel producers. We shall continue to do so and our customers will benefit. It is our contribution to our continued freedom, a priceless benefit that we all enjoy.

WISCONSIN STEEL COMPANY, Affiliate of INTERNATIONAL HARVESTER COMPANY
180 North Michigan Avenue • Chicago 1, Illinois

WISCONSIN STEEL

Coil Springs are Accurately Hardened in a HEVI DUTY Combustion Tube FURNACE



A Hevi Duty hinged tube electric furnace in use at the Borg Products Division of the George W. Borg Corp., Delavan, Wisconsin.

PRECISE heat treating of hairsprings used in the automobile clocks manufactured at the Borg Products Division is accomplished in a Hevi Duty hinged tube furnace. A controlled atmosphere is utilized to provide a bright surface on the work.

The increased use of Hevi Duty Combustion Tube furnaces as production tools, and their varied applications in analytical research, has caused them to become standard with many manufacturers. For complete details send for Bulletin HD1236.

HEVI DUTY ELECTRIC COMPANY

HEAT TREATING FURNACES HEVI DUTY ELECTRIC EXCLUSIVELY

DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS

MILWAUKEE 1, WISCONSIN

For maximum van trailer lightness, manufacturer designs floor of Dow

MAGNESIUM

the world's lightest structural metal!

Magnesium Extrusions— light, strong, versatile

To withstand the severe shock and bending loads imposed by fork lift trucks, the manufacturer designed this lightweight multi-ribbed section. Here again the flexibility of the magnesium extrusion process made it possible to tailor this lightest of structural metals to job requirements—cutting fabrication costs to a minimum.

More than 650 lb. of costly dead weight removed from a 32-foot van trailer! That's what happened when a leading manufacturer designed a floor made up of *full length* extruded magnesium "boards".

Not only does the extruded magnesium floor weigh significantly less than the heavy floor it replaced, it is also 83% stronger and requires much less maintenance. In addition, the new floor is free from troublesome splinters and does not pick up objectionable odors from the cargo.

Magnesium is a wise choice for lightweight strength and durability. A full one-third lighter than any other structural metal, magnesium's high strength-weight ratio permits strong, rigid designs of surprising lightness. Magnesium is versatile, too. Available in all common forms, it is easily fabricated by simple, established shop procedures. For technical information about magnesium, call your nearest Dow sales office, or write Dept. MG-62 in Midland.

Magnesium Division

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

New York • Boston • Philadelphia • Washington • Atlanta • Cleveland • Detroit
Chicago • St. Louis • Houston • San Francisco • Los Angeles • Seattle
Dow Chemical of Canada, Limited, Toronto, Canada

Lighter Products Sell—make your products Magnesium Light!

It's no time to fiddle!

HEADLINES warn us of the menace of spies and subversive agents. But in every community there is a hazard, largely unrecognized, which may become ready tinder for the ravaging flames of socialism and communism. This is the misconception of everyday economic facts that exist among our young people.

For example, a recent poll among high school seniors shows that the majority of them believe that the owners of business take out for themselves a larger share of the income than is paid to employees. They think the stockholders' average return is 24% of the sales dollar. The truth is that stockholders average less than 3%, whereas over 30% of the income dollar is paid out as wages, pensions and other benefits.

Our young people do not seem to realize that paying dividends is only one function of profits. Far more important today is the need for profit to keep business competitive, and to pay for new buildings, machinery, and other necessary equipment and to provide new and more jobs. Ignorance of this fundamental concept breeds contempt for the system of enterprise that built our country and keeps it strong.

The facts of business must be given to our boys and girls to protect their future. Only business men can supply the facts. As a business leader in your community, it is your responsibility to help clear up such misconceptions. The old story that Nero fiddled while Rome burned must not have a counterpart in America.

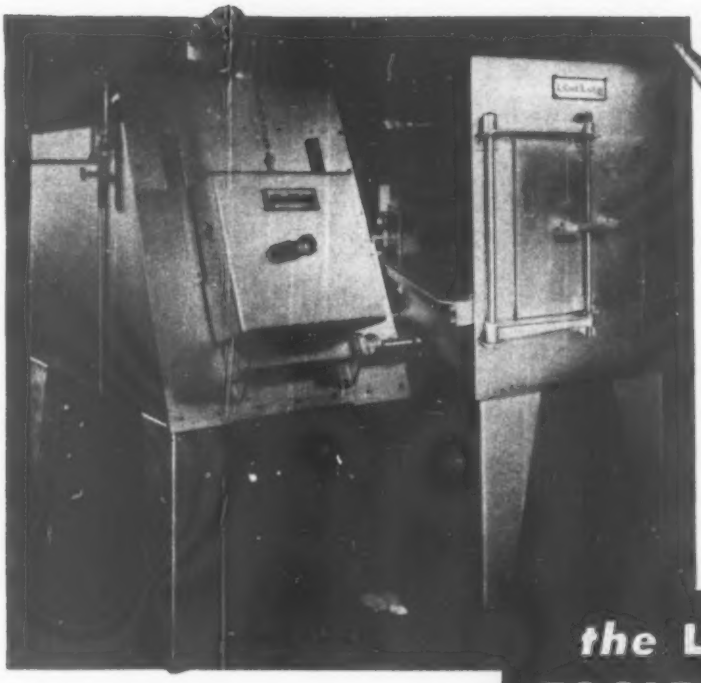
The Youngstown Sheet and Tube Company

General Offices – Youngstown 1, Ohio

Export Offices--500 Fifth Avenue, New York

MANUFACTURERS OF CARBON ALLOY AND YOLOY STEELS

RAILROAD TRACK SPIKES - CONDUIT - HOT AND COLD FINISHED CARBON AND ALLOY BARS - PIPE AND TUBULAR PRODUCTS - WIRE - ELECTROLYTIC TIN PLATE - COKE TIN PLATE - RODS - SHEETS - PLATES.



BASIC FOR EVERY TOOLROOM

the LINDBERG TOOLROOM TEAM

When production depends on tools and dies, tools and dies depend on the LINDBERG TOOLROOM TEAM—a basic requirement in every toolroom—a must where you want the ultimate in tools and dies which will keep your production rate up and your machinery running with a minimum of tool and die failure. The LINDBERG TOOLROOM TEAM gives you the precision heat treating which your precision tools and dies need for lasting performance.

LINDBERG HARDENING FURNACE—eliminates finishing due to scale and decarb with simple accurate atmosphere control.

LINDBERG TEMPERING FURNACE—allows you to obtain the exact "Rockwell Hardness" required for each specific tool or die.

For tools and dies requiring high speed tool steel—investigate the Lindberg "L" Type combination preheat—high heat Furnace.

LINDBERG FURNACES

LINDBERG ENGINEERING COMPANY W. Hubbard Street, Chicago 12, Illinois

Memo to all Forge Shops!

The best way to produce odd-shaped forgings is to pre-form the blanks in REDUCEROLLS and finish-forge them in MAXIPRESSES.

No. 4 REDUCEROLL

No. 6A MAXIPRES

THIS DOOR IS ALWAYS OPEN

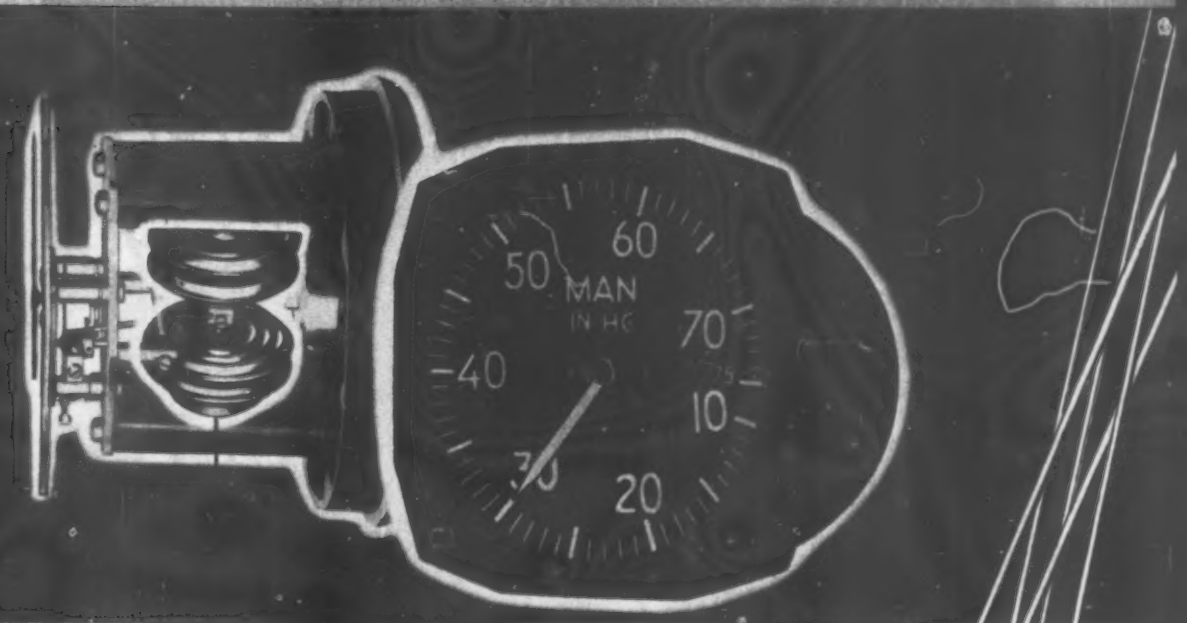
We shall be pleased to assist you with your forging problems. Our entire organization is available to you. Send us blueprints or a sample of the part you wish to forge. Better yet, visit us. No obligation, of course.

NATIONAL
MACHINERY COMPANY
TIFFIN, OHIO.

DESIGNERS AND BUILDERS OF MODERN FORGING MACHINES—MAXIPRESSES—COLD HEADERS—AND BOLT, NUT, RIVET, AND WIRE NAIL MACHINERY

New York Detroit Chicago

THIS TIRELESS METAL THAT KEEPS GAUGES HONEST MAY REVOLUTIONIZE YOUR PRODUCTS



United States Gauge, world's largest manufacturer of gauges, uses Riverside Beryllium Copper for both pressure and vacuum diaphragm capsules of its absolute pressure instruments.

There's no place for muscle-bound metals in the diaphragms of an absolute pressure gauge. Constantly *sensing and reporting* changes in manifold pressure of internal combustion engines, diaphragms must be super-sensitive yet rugged enough to withstand flexure.

Beryllium copper, one of the alloys made by Riverside, is the only metal possessing the necessary physical properties that will do the job economically. In this application beryllium copper is "cold worked" to a tensile of 80,000 pounds, and formed *while being heat treated* to a tensile of about 210,000 pounds. Beryllium copper diaphragms easily take the initial stresses caused by evacuating air and the ever changing stresses of flexure.

Because of these advantages—plus corrosion resistance, wear resistance, formability and superior electrical and thermal qualities—Riverside *Beryllium Copper* finds wide use in gauges, springs, thermostats, bearings, gears, valve sleeves and seats. This versatile alloy—or one of the other Riverside metals, *Phosphor Bronze, Nickel Silver* or *Cupro Nickel*—may be the specific answer to your alloy problem. We produce these alloys in standard or special grades to meet your requirements. And we'll be glad to work with your technicians in examining and solving your particular puzzle.

If alloys are giving you trouble—in processing or in service—send the case history to Riverside. Also, be sure to ask for our new pocket-size Alloy Handbook. It's invaluable as a handy reference and a guide to alloy specification—and it's yours without obligation.

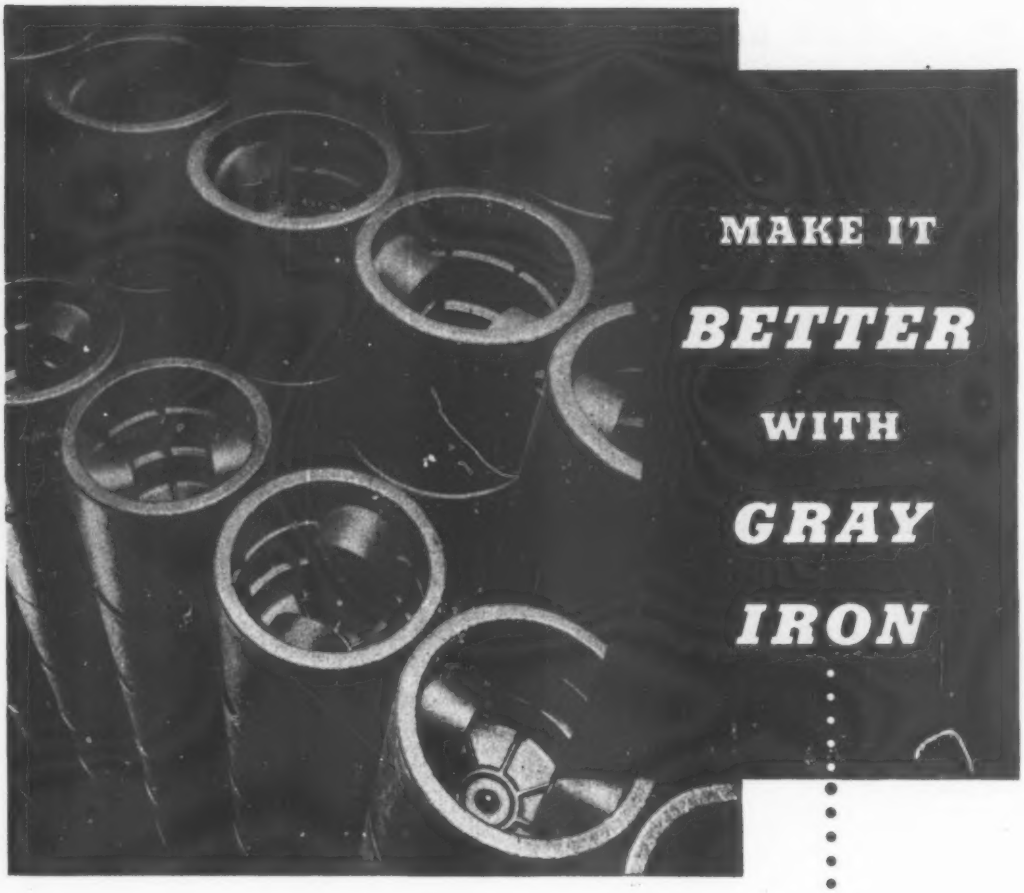
RIVERSIDE ALLOYS

Alloys developed by research proved by use

phosphor bronze
•
nickel silver
•
cupro nickel
•
beryllium copper

THE RIVERSIDE METAL COMPANY
Riverside, New Jersey
Newark, N. J. • Cleveland, Ohio • Chicago, Ill.
Hartford, Conn. • Rochester, N.Y. • Detroit, Mich.

Export Agent: International Nickel & Copper Co., Inc., 67 Broadway, New York City



These lightweight pistons of Gray Iron illustrate a number of the important qualities of this versatile metal.

Wear resistance, of course, is of prime importance here. By alloying and heat-treating Gray Iron you can further increase its strength and wear resistance to almost any desired specification. Thermal stability is another useful quality. Castability to precise dimensions is important, too.

Look over this unmatched combination of properties which Gray Iron offers. Are you taking full advantage of these in your products . . . plus Gray Iron's ultimate economy?

Gray Iron Characteristics Include:

Castability	Wear Resistance	Machinability
Rigidity	Heat Resistance	Vibration Absorption
Low Notch Sensitivity	Corrosion Resistance	Durability
	Wide Strength Range	

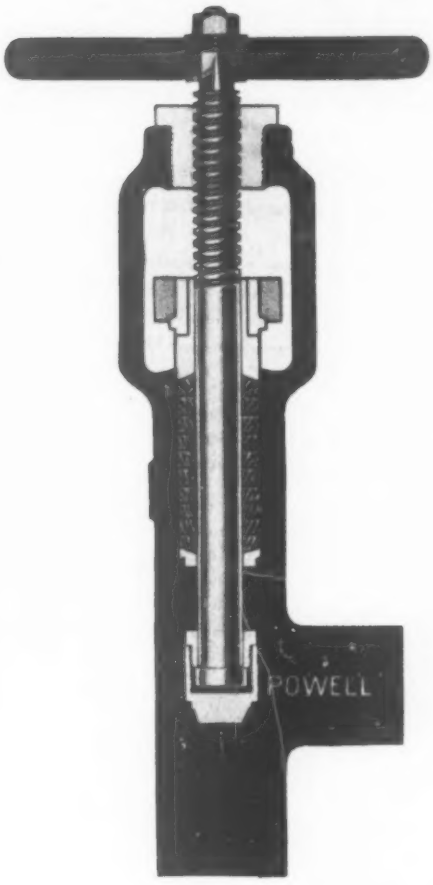
Make It Better with Gray Iron

Second largest industry in the metal-working field

GRAY IRON FOUNDERS' SOCIETY, INC.

NATIONAL CITY-E. 6th BLDG. CLEVELAND 14, OHIO

How TIMKEN® DM-2 steel helps new valve solve a heat and pressure problem



THE new Powell Bonnetless Valve is used on small piping systems and on by-passes of larger valves. It has to withstand the kind of temperatures and pressures that produce creep in most steels below the stainless group.

Designers answered the problem by making the valve body of Timken® DM-2 alloy steel (in red on diagram of valve at left). This remarkable steel—developed by Timken Company metallurgists—has outstanding creep strength at temperatures up to 1100° F.

Timken DM-2 is recommended for jobs that have used standard .50 Mo steel in the past. Besides having greater creep strength, DM-2 has better corrosion and oxidation resistance. It will not graphitize. Its tensile properties are practically unchanged by long heating under stress at 1100° F.

These advantages make Timken DM-2 an ideal steel for high pressure boiler tubing, superheater tubing and high temperature steam piping, as well as valve parts.

For complete data contact our Technical Staff. Also write on your business letterhead for "Timken Pressure Tubes and Piping". The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

POWELL BONNETLESS VALVE *is made by The William Powell Company, Cincinnati, Ohio. Portion of diagram in red shows Timken DM-2 steel body.*

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing.

For the Production Engineer's Notebook—

Ideas for Welded Design

Product engineers, even the geniuses among them, find that the formula, "1% inspiration, 99% perspiration,"* pretty regularly applies.

Perspiration in design is brought about by the inevitable conflict between operating function—how well the part will do its job—and such other important factors as sales appeal, serviceability, and manufacturing methods.

What we are all striving for is to apply welding most economically. We in LINDE stand ready to help the product engineer in the applications of welding methods wherever we can. Sometimes economies in production come from a substitution of welding for more expensive methods, but often just a small change in design or practice reduces the cost of present welding operations.

Pointers on welded design leading to production economies.

Use the process that gives the greatest total economy.

Design for down-hand welding where possible. But locate welds so as to minimize handling.

Mechanize welding. Weld as many joints simultaneously as possible.

Make minimum dimension changes when making different sized models.

Reduce the number of parts. But sometimes it is better to increase the number of parts and cut rejects in intricate castings or forgings by welding together simple forms.

Use standard shapes and easily formed sections.

Pointers on welding processes leading to production economies.

UNIONMELT welding: high speed process for deep-penetrated welds—minimum cleaning and finishing—no spatter, sparks, or smoke—usually mechanized—will make butt, tee, and lap fillets, plug, and molded welds. Used for most ferrous and many non-ferrous metals. Ask LINDE for booklet F-6077.

HELIARC welding: used for most metals, especially aluminum, magnesium, stainless steel, and copper alloys. Particularly useful for sheet steel. Manual or mechanized—high speed—greatest feature is minimized cleaning and finishing because of flux and spatter elimination. Ask for booklet F-6291.

Take advantage of other economies that are inherent in such oxy-acetylene processes as flame-cutting, welding, surfacing, hardening. For more information on any of these processes call or write to The Linde Air Products Company, offices in principal cities.

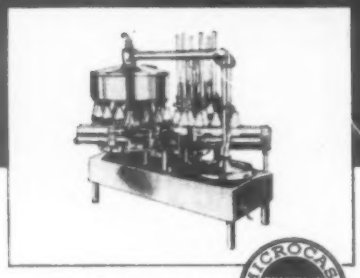
* "Genius is 1% inspiration and 99% perspiration," credited in GOLDEN BOOK, April, 1931, to a newspaper interview with Thomas A. Edison.

THE LINDE AIR PRODUCTS COMPANY
Unit of Union Carbide and Carbon Corporation
30 E. 42nd St., New York 17, N. Y. UCC Offices in Other Principal Cities
In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto
The terms "Heliarc" and "Unionmelt" are registered trade-marks.

MICROCASTINGS
Cut Cost 60%
ELIMINATE POROSITY • MACHINING

Part Name: **Stabilizer**
Utilization: **Milk Bottling Equipment**
Alloy: **302 Stainless Steel**

Health Department Standards require porosity-free stainless steel for this part, which comes in direct contact with milk. Producing the stabilizer from sand casting resulted in a loss from porosity, a condition usually inherent in a casting of this size and requiring expensive machining to correct. Likewise, machining the part from bar stock was also a costly operation. The Microcast Process of precision casting effected a 60% saving over the previous method of manufacture, as well as eliminating considerable waste stock and expensive tools.



MICROCAST T. M. REG. U. S. PAT. OFF.

MICROCAST components, as cast, are structurally sound, dimensionally uniform, and cast to such close tolerances that little or no machining is needed. Intricate shapes such as this can be specified in such extremely hard, non-machineable, non-forgeable alloys as stainless steel, tool steel, Stellite, and others. Write for complete technical information.

WRITE FOR FREE MICROCAST MANUAL

The Microcast Process is graphically described in this 16-page booklet. Many applications are shown, together with specifications and step-by-step explanation. Write today!

MICROCAST

MICROCAST DIVISION
AUSTENAL LABORATORIES, INC.
224 East 39th Street • New York 16, New York
715 East 69th Place • Chicago 37, Illinois

Buehler...

Operator using the new Model No. 1506 low speed polisher. Section of laboratory equipped with No. 1251 Duo Belt Sander—No. 1700 Electro Polisher—No. 1315 Press.

THE BUEHLER LINE OF SPECIMEN PREPARATION EQUIPMENT INCLUDES . . . CUT-OFF MACHINES • SPECIMEN MOUNT PRESSES • POWER GRINDERS • EMERY PAPER GRINDERS • HAND GRINDERS • BELT SURFACERS • MECHANICAL AND ELECTRO POLISHERS • POLISHING CLOTHS • POLISHING ABRASIVES

METALLURGICAL LABORATORY EQUIPMENT

. . . provides the metallurgist with the most complete line of modern designed precision machines for specimen mounting and preparation available anywhere in the world. This finely made equipment has been developed through a thorough understanding of the requirements of the metallurgist and a rigid insistance on perfection in the mechanical design and construction of each item.

Everything needed for metallurgical testing from cut-off machines, moulding presses, and grinders to the mechanical or electrolytic polishers is included in the Buehler line.

In setting up complete laboratories or adding items to present equipment the metallurgists will find in the Buehler line of coordinated equipment everything needed for producing the best work, with speed and accuracy.

Write for bulletin of new equipment or information on any specific item. We invite correspondence relative to setting up complete laboratories suitable for any particular requirement.

Exclusive U. S. agents for Amsler and Chevenard Testing Machines.

Buehler Ltd.
A PARTNERSHIP

METALLURGICAL APPARATUS
165 WEST WACKER DRIVE, CHICAGO 1, ILL.

Always demand the best in

Castings—get Accoloy, then

Check your production costs . .

Only then can you prove the

Long service performance

Of top quality castings . .

Year in and year out.

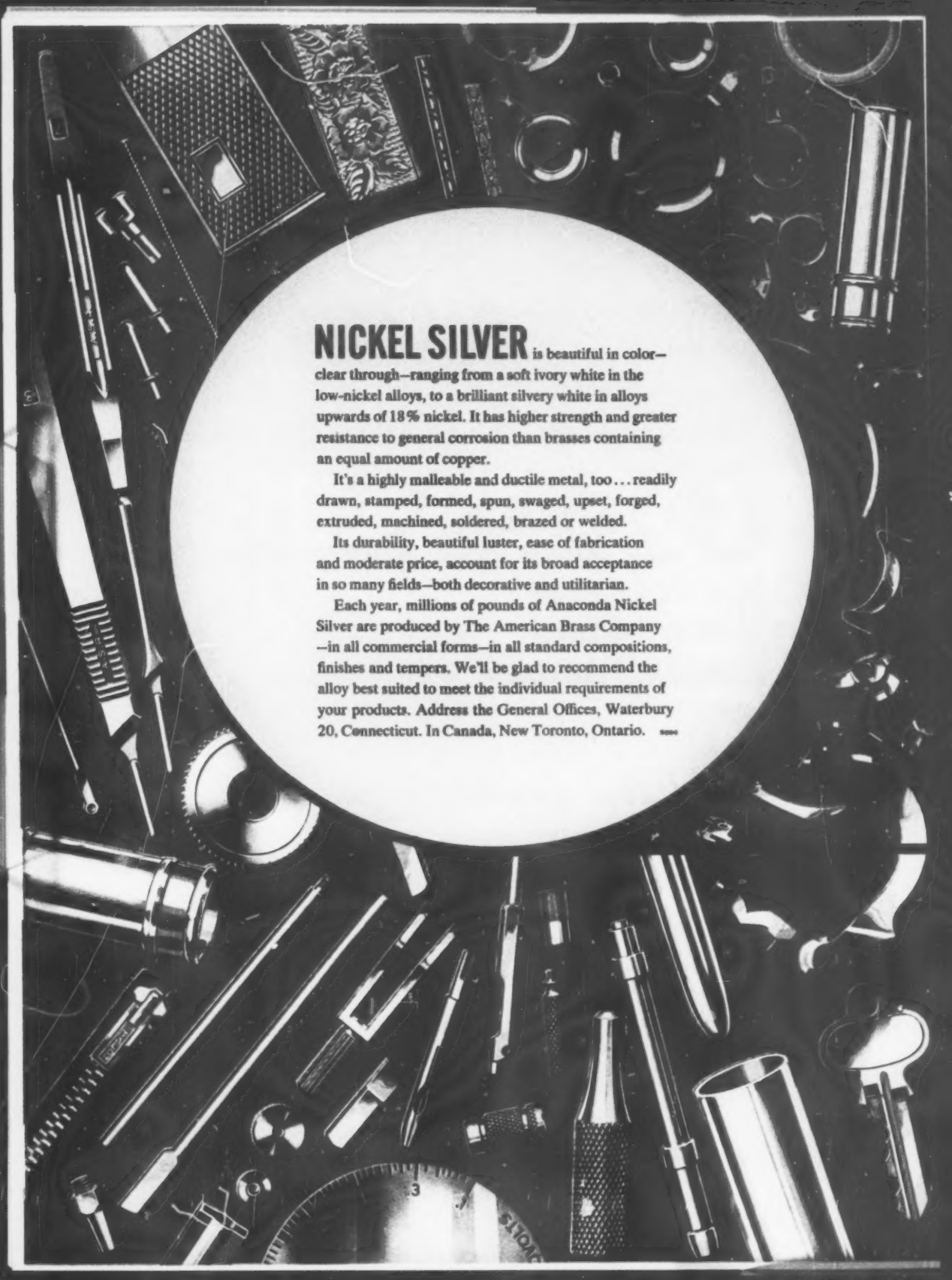
HEAT RESISTANT CASTINGS
ACCOLOY
STAINLESS STEEL CASTINGS

ALLOY ENGINEERING & CASTING COMPANY

ALLOY CASTING CO. (Div.)

CHAMPAIGN • ILLINOIS

ENGINEERS AND PRODUCERS OF HEAT AND CORROSION RESISTANT CASTINGS

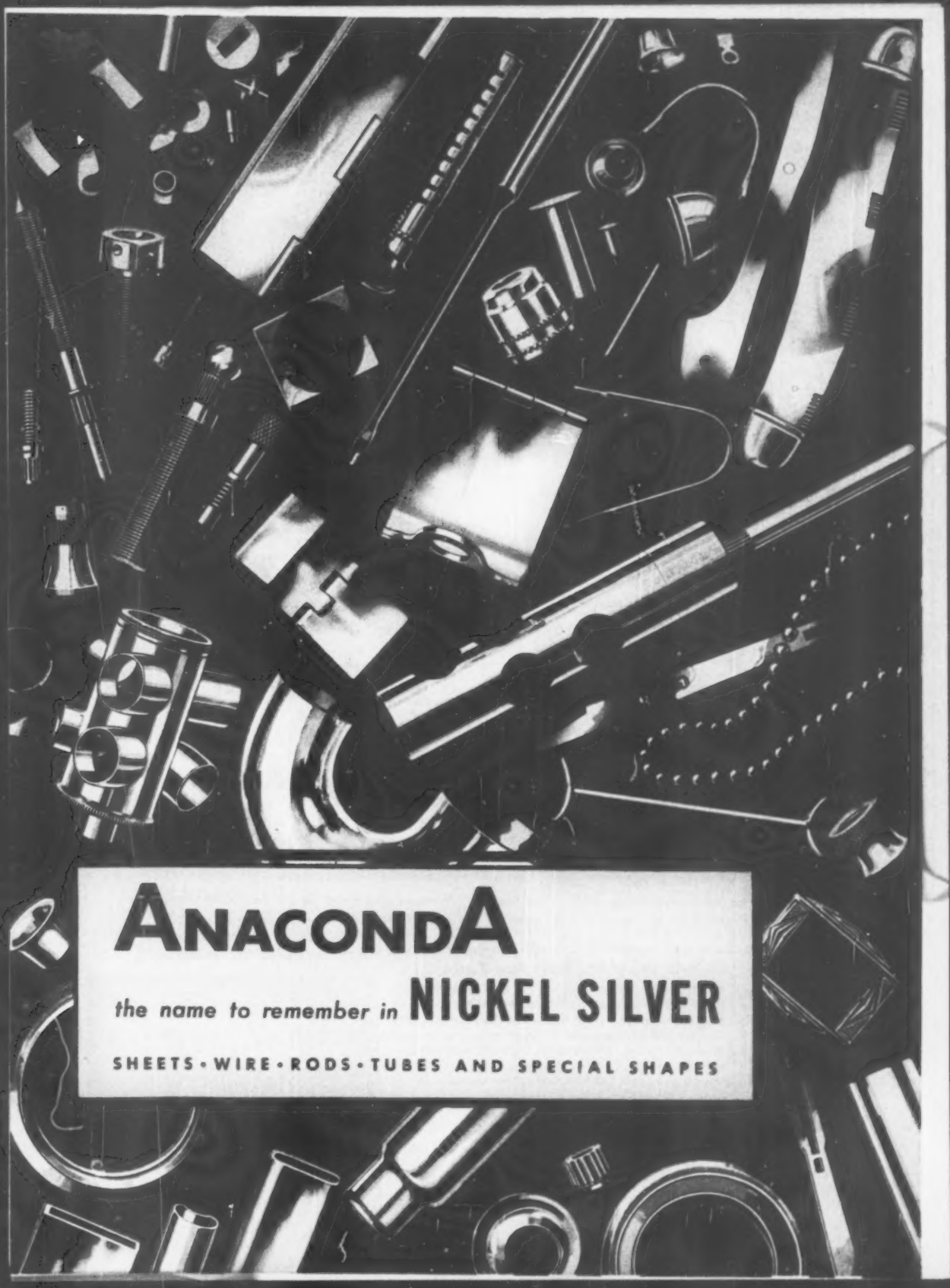


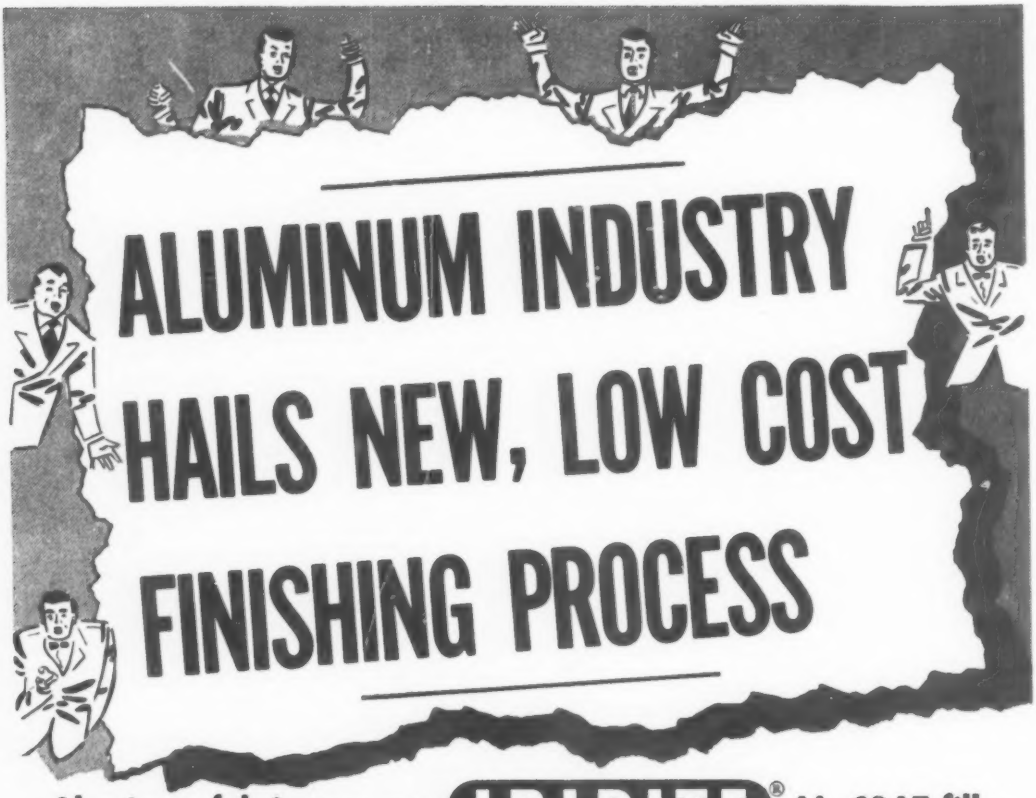
NICKEL SILVER is beautiful in color—clear through—ranging from a soft ivory white in the low-nickel alloys, to a brilliant silvery white in alloys upwards of 18% nickel. It has higher strength and greater resistance to general corrosion than brasses containing an equal amount of copper.

It's a highly malleable and ductile metal, too... readily drawn, stamped, formed, spun, swaged, upset, forged, extruded, machined, soldered, brazed or welded.

Its durability, beautiful luster, ease of fabrication and moderate price, account for its broad acceptance in so many fields—both decorative and utilitarian.

Each year, millions of pounds of Anaconda Nickel Silver are produced by The American Brass Company —in all commercial forms—in all standard compositions, finishes and tempers. We'll be glad to recommend the alloy best suited to meet the individual requirements of your products. Address the General Offices, Waterbury 20, Connecticut. In Canada, New Toronto, Ontario.


ANACONDA
the name to remember in NICKEL SILVER
SHEETS • WIRE • RODS • TUBES AND SPECIAL SHAPES



ALUMINUM INDUSTRY HAILS NEW, LOW COST FINISHING PROCESS

Aluminum fabricators say IRIDITE® AL-COAT fills long-sought need for non-electrolytic corrosion resistant coating

Now you can apply a clear protective Iridite film to mill or buffed aluminum surfaces in as little as 10 seconds . . . without changing the appearance of the metal. Or, a highly protective yellow colored film can be produced from a one to two minute immersion.

Since its introduction, Iridite Al-Coat has been widely acclaimed for its ease and speed of application, superior corrosion resistance and low cost. Because of its simple operation, Iridite Al-Coat is replacing more complicated and expensive electrolytic processes for providing a corrosion resistant final finish or paint base for aluminum surfaces.

Write or wire direct, or ask your Iridite representative for full information and samples. Or, send us a sample of your product for test processing.

Here's Why It's Best For You . . .

APPLICATION—*Dip, spray or brush* . . . **ONE SOLUTION**—*No heat or current—single dip* . . . **FAST PRODUCTION**—*Few seconds to 2 minute immersion* . . . **CORROSION RESISTANCE**—*Up to 1,000 hours salt spray on wrought stock, 250 hours on castings. Meets all military specifications* . . . **ABRASION RESISTANCE**—*No flaking or peeling from buffing, bending or scraping* . . . **PAINT BASE**—*Blocks underfilm corrosion* . . . **APPEARANCE**—*Color selection—clear or yellow* . . . **WELDABILITY**—*Can be spot welded, aids shielded-arc welding* . . . **CONDUCTIVITY**—*Low surface electrical resistance* . . . **LOW COST**—*SAVES UP TO 50% OVER OTHER PROCESSES*

ALLIED RESEARCH PRODUCTS, INC.

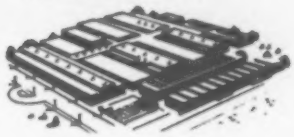
[illegible] EAST MONUMENT [illegible]

[illegible] BALTIMORE [illegible] MD.

REPRESENTATIVES IN PRINCIPAL INDUSTRIAL CITIES; WEST COAST—L. H. BUTCHER CO.

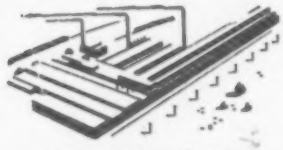
MANUFACTURERS OF IRIDITE FINISHES FOR CORROSION RESISTANCE AND PAINT SYSTEMS FOR NON-FERROUS METALS; ARP PLATING CHEMICALS

CLEVELAND, OHIO



Sand & Permanent Mold Foundries

DETROIT, MICHIGAN



Permanent Mold Foundry

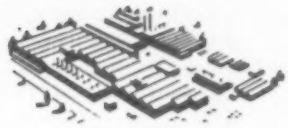
Carefully cast by the thousands at

In diesel bearings or any other casting, the larger the quantity—the tougher your designs—the more Alcoa foundries can save you. With modern equipment and 62 years of aluminum experience, Alcoa tackles castings that others balk at.

If you want lighter products—easier handling—faster machining—freedom from finishing—you want aluminum castings.

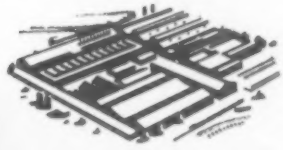
Look for Aluminum Company of America listed under "aluminum" in your phone book. Call there for an Alcoa specialist, or write: ALUMINUM COMPANY OF AMERICA, 1993G Gulf Bldg., Pittsburgh 19, Penna.

BRIDGEPORT, CONN.



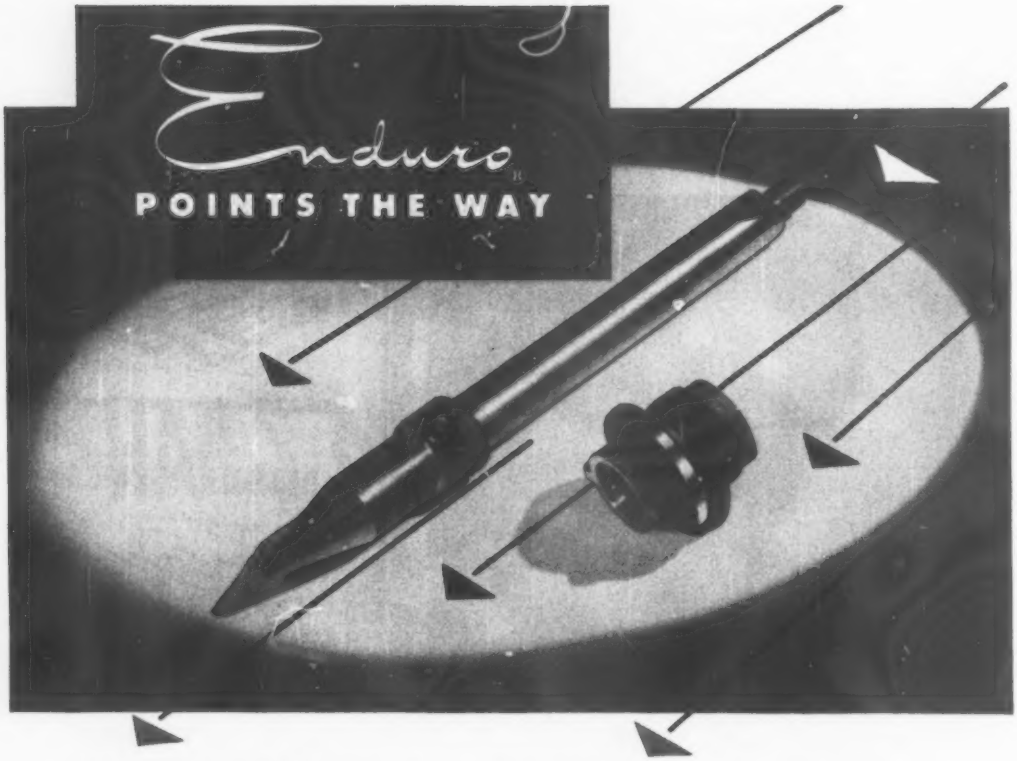
Sand & Permanent Mold Foundries

LOS ANGELES, CALIF.



Sand & Permanent Mold Foundries

ALUMINUM CASTINGS *by* ALCOA



Machinability plus Corrosion • Resistance

High machinability . . . unsurpassed corrosion-resistance . . . here are two of the many good reasons why it pays to use Republic ENDURO Stainless Steel in Free-Machining analyses.

In this stainless steel needle valve and seat used in oil well flow lines, for example, high machinability is obtained from ENDURO type 420-F bar stock. Corrosive crude oil has little effect upon these parts which would be short-lived if made of carbon steel.

A product of Republic's famed Union Drawn Division, ENDURO Cold-finished Bars are consistently uniform in accuracy of section, fine surface finish and MACHINABILITY. Add ENDURO's natural sanitation, heat-resistance, high strength and ease of cleaning, and you have *all* the reasons for using them in YOUR PRODUCT.

For further information about ENDURO Stainless Steel Bars—cold finished, hot rolled and wire—write *today*.

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, N.Y.

Republic® ENDURO® FREE-MACHINING STAINLESS STEEL

REPUBLIC STEEL

Other Republic Products include Carbon and Alloy Steels—Pipe, Sheets, Strip, Plates, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing

"With **Gulf Soluble Cutting Oil**

we eliminated rusting of work in process,"

says this Asst. Superintendent

"With the soluble oil we used previously, steel parts rusted between machining operations," says the Assistant Superintendent of this machine shop. "Now we use Gulf Soluble Cutting Oil—1 to 20 mix—and this problem has been eliminated. Finished surfaces stay bright. This speaks well for Gulf Soluble Cutting Oil since some of the parts must be protected for as long as two weeks."

Other properties which make Gulf Soluble Cutting Oil the preferred cutting fluid in scores of machine shops: It emulsifies readily with all but the hardest water; forms a stable emulsion; and is nonfoaming.

Gulf Oil Corporation · Gulf Refining Company

GULF BUILDING, PITTSBURGH, PA.

Sales Offices - Warehouses

Located in principal cities and towns throughout Gulf's marketing territory

For further information on Gulf Soluble Cutting Oil—and for one of Gulf's practical slide-rule-type calculators which will help you maintain desired soluble oil concentrations—send the coupon below.

Gulf Oil Corporation · Gulf Refining Company MP
Pittsburgh 30, Pa.
Please send me, without obligation, the material I have indicated below:

- ☐ Further information on the new Gulf Soluble Cutting Oil.
- ☐ Practical Slide-rule-type calculator for help in maintaining desired soluble oil concentrations.

Name .....
Company .....
Title .....
Address .....

GULF INDUSTRIAL LUBRICATION

Advertisement

ELECTROMET Data Sheet

A Digest of the Production, Properties, and Uses of Steels and Other Metals

Published by Electro Metallurgical Division, Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, N. Y. • In Canada: Electro Metallurgical Company of Canada, Limited, Welland, Ontario

VANADIUM...the metal that accentuates the effects of other alloying elements

Vanadium is usually added to steel or iron along with other alloying metals, such as manganese, tungsten, nickel, or chromium. It enhances the effect of these other alloys and helps to improve the physical properties of the metal. Generally it is used in quantities of less than 0.50 per cent, but even in these small amounts it is responsible for many marked improvements in the quality of iron and steel.

One of the most notable functions of vanadium is its effect in improving the dynamic properties of steel, such as fatigue and impact resistance. It also gives an inherently fine grain size to both steel and iron.

In high-speed tools, vanadium contributes wear resistance and red hardness. It is also an important alloy in many types of permanent magnet steels. These and many other types of special-purpose steels contain more than 0.50 per cent vanadium to enhance certain properties.

Dynamic Strength for Steels

The principal effect of vanadium in engineering steels is that of refining grain size. It is usually added in amounts of 0.10 to 0.25 per cent.

Fig. 1. Steels in which vanadium is an alloy have outstanding dynamic strength. That is why they are frequently used in such heavy-duty service as springs and axles in diesel locomotive trucks.

In the lower carbon ranges, vanadium steels are especially suited for carburizing and are used for such applications as hand tools, bearings, and pistons. Vanadium-bearing steels can also be nitrided effectively.

Vanadium contributes fatigue and impact resistance and also strength and ductility to spring steels. The famous chromium-vanadium (SAE 6100 series) and manganese-vanadium spring steels are outstanding examples of this use. Besides being used as springs, these steels are frequently used for axles, shafts, and other highly stressed moving engine parts.

Red Hardness in Tools

Practically all fine tool steels contain vanadium. In high-speed steels, vanadium content usually ranges from about 0.50 to 2.50 per cent, although higher percentages are sometimes used. Other alloy tool steels usually contain from 0.20 to 1.00 per cent vanadium.

Vanadium is a strong carbide former and forms very hard and stable carbides. These vanadium-carbides are probably the main reason for the excellent wear resistance and edge-holding properties of vanadium tool steels. The persistence of the vanadium-carbides is largely responsible for the cutting qualities at red hardness of high-speed tool steels.

Adds Strength to Cast Iron

In amounts of 0.10 to 0.15 per cent, vanadium increases the strength of cast iron from 10 to 25 per cent, and adds a considerable amount of toughness. Cast iron containing vanadium is especially valuable in such applications as steam locomotive cylinders, valve and piston bushings, piston rings, and similar parts. In steam engines and diesel motors, vanadium cast iron cylinders greatly outlast those of ordinary cast iron. Chromium-vanadium cast iron rolls, containing up to 2 per cent chromium, have been used successfully in steel mills for a great many years.

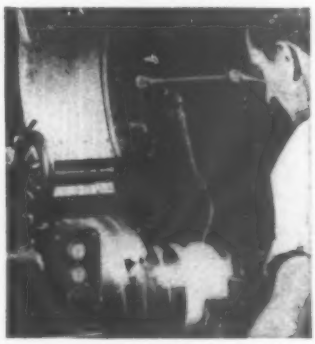


Fig. 2. Nearly all fine tool steels contain vanadium. It promotes fine grain size, high wear resistance, and greater control of hardenability. Vanadium also contributes to the red hardness of high-speed tool steels.

Cast iron in which vanadium is the sole alloying element is used primarily in applications where temperatures are moderately high and in heavy sections requiring uniform hardness without brittleness.

ELECTROMET Vanadium Alloys

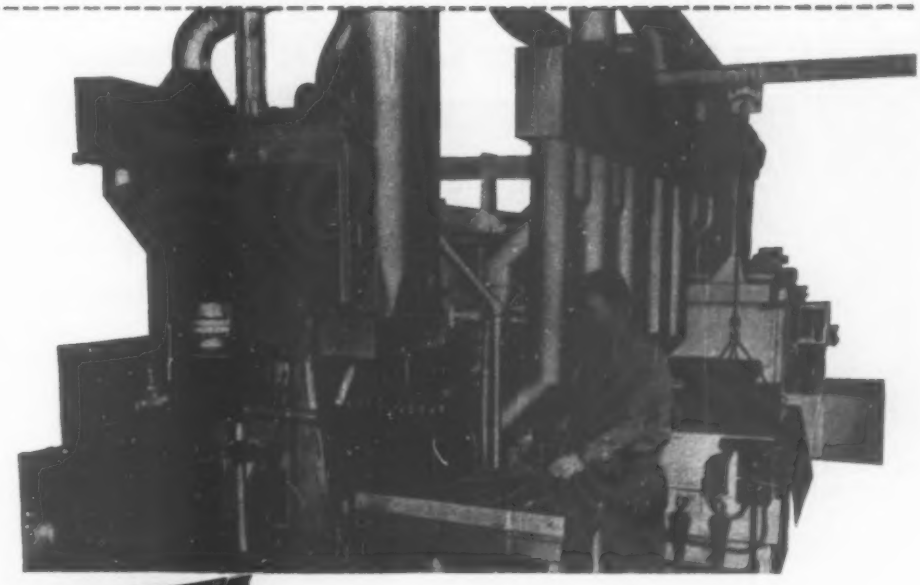
ELECTROMET produces three grades of ferrovanadium in various sizes for the production of vanadium-bearing steels and irons. Each grade has a definite range of carbon and silicon contents and is especially adapted to assure the best results in the different requirements of iron and steelmaking.

Write for a copy of the booklet, "ELECTROMET Ferro-Alloys and Metals." It contains many useful facts about the use of ferrovanadium. The booklet also describes over 50 other alloys and alloying metals produced by ELECTROMET.

The term "Electromet" is a registered trademark of Union Carbide and Carbon Corporation.

YOU CAN BE **SURE**.. IF IT'S

Westinghouse



FOR THE MAN WHO CAN'T BE SOLD

Here's the solution to your Gas Carburizing Problems

Westinghouse Therm-a-neering has the answers. This engineering and metallurgical service is offered with no obligation to the man who "can't be sold", but, who is willing to accept *proof* of efficiency and dependability. Therm-a-neering custom-builds equipment to fit your individual requirements, assuring smooth and economical operation of your heat-treating line.

Take the carburizing furnace shown above, for example: one continuous and complete operation puts all parts through the same cycle, same atmosphere, same temperature. Uniformity of parts is assured. Rejects are eliminated.

And the work is done fast. No handling of parts is required between charging and discharging. Doors open automatically. One operator handles all work easily. Production is maintained at 800 net pounds per hour.

This installation is typical of the way Westinghouse furnaces—both gas-fired and electric—are answering today's production problems. And because Westinghouse engineers have no favorite to play, they can study your problems from an unbiased point of view in helping you select the equipment to do your job most efficiently and economically.

Let Therm-a-neering help you. Call your nearby Westinghouse representative for details, or write Westinghouse Electric Corporation, 181 Mercer St., Meadville, Pa. J-10350

Therm-a-neering. **A HEAT AND METALLURGICAL SERVICE THAT OFFERS WITHOUT OBLIGATION:**

ENGINEERS—Thermal, design and metallurgical engineers to help you study your heat-treating problems with a view toward recommending specific heat-treating furnaces and atmospheres.

RESEARCH—A well-equipped metallurgical laboratory in which to run test samples to demonstrate the finish, hardness and metallurgical results that can be expected on a production basis.

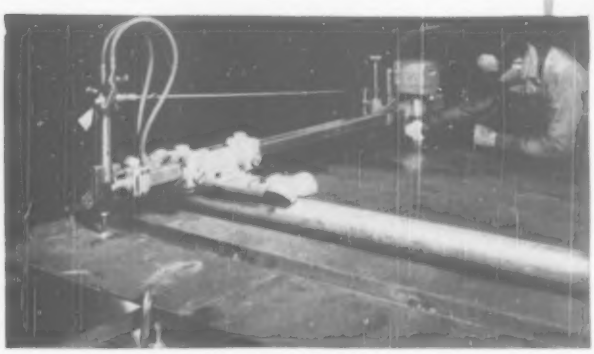
PRODUCTION—A modern plant devoted entirely to industrial heating.

EXPERIENCE—Manufacturers of a wide variety of furnaces—both gas and electric—and protective atmosphere generators.

GAS AND ELECTRIC

"We can't say enough about Airco's NEW No. 3 Monograph . . . its portability, accuracy and shape cutting versatility make it a MUST for every metal working shop..."

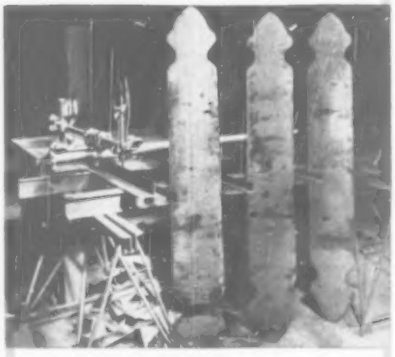
Says Mr. J. C. Hustad, President
Hustad Company, Minneapolis, Minn.



Used for machine gas cutting of special structural shapes at Hustad, the Airco No. 3 Monograph has more than proved its ability to meet the demand for straight line, circle and bevel cutting, with an extremely high degree of accuracy.

Further, with a cutting area of 32 inches by 56 inches, it gives excellent results in cutting most any steel shape up to 8 inches thick . . . and a 6-foot 8-inch rail can be added, extending the cutting area indefinitely.

This NEW machine is the lowest priced machine of its type in the field (only $695, including a manual tracing device, torch, tip, tubular rail, hose and carrying case). Also, it is portable—the machine itself weighs but 110 lbs. and the tubular rail 35 lbs. The entire unit is packed in a carrying case which can be conveniently handled by two men.



SPECIAL TRIAL OFFER
(Good in Continental U.S.A. Only)

If you would like to try this machine for two weeks *in your own shop on your own work*, just drop a letter to your nearest Airco office or authorized Airco dealer and they will advise you how a shop-trial can be arranged . . . or, if you would like a descriptive folder (ADC-660) they will be glad to send you a copy.

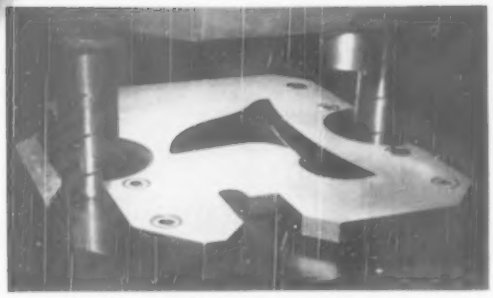
This shows a clevis for a steel mill guide cut from 6" plate—note the smoothness of the cut, reducing considerably machining cost and time.

AIRCO **AIR REDUCTION**
Offices in Principal Cities

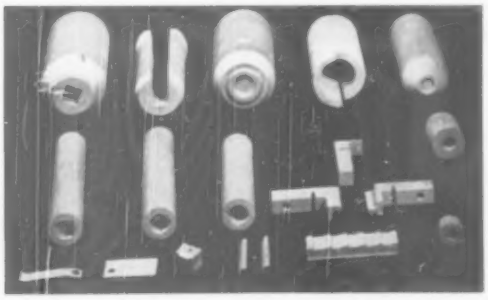
Headquarters for Oxygen, Acetylene and Other Gases . . . Calcium Carbide Gas Cutting Machines . . . Gas Welding and Cutting Apparatus and Supplies . . . Arc Welders, Electrodes and Accessories.

MANUFACTURING PLANTS · MACHINE SHOPS
SHIPYARDS · FORGE SHOPS · ROLLING MILLS
MINES · FOUNDRIES · FABRICATING WORKS

This tool steel proving ground means better tool performance



This blanking die is made from Lehigh H, our popular high-carbon, high-chrome steel for long production runs. Made in one of our own tool-rooms, this die produces parts from $\frac{1}{16}$-in. steel plate for our weldment shop at the Bethlehem, Pa., plant.



These automatic bolt-header parts are typical of the many uses at our Lebanon, Pa., plant for our carbon tool steel (cold-heading quality) and Bethlehem hot-work and shock-resisting steels.

We are makers of tool steel, and large users as well. We use hundreds of tons of Bethlehem Tool Steels every year. Tools and dies, made from dozens of our different grades, are put to work on production jobs in Bethlehem shipyards, mines, machine shops, foundries, forge shops, rolling mills, fabricating works and manufacturing plants.

Knowing exactly how to treat and apply a tool is often just as important as the inherent quality of the tool steel. By making full use of our tremendous proving grounds we've learned a whale of a lot about tool steel. On one job, for example, we may match three grades against each other. In another case we may try several different heat-treatments on one steel in order to achieve the best properties for a shear blade, a tool bit, or a punch. Improved grades of tool steel are often the direct result of long observance of tool performance in our own shops.

By putting tool steels to work among our own family, we gather reliable facts with which to supplement the findings of our laboratories. All of this leads to finding better ways to heat-treat tools, improved techniques in forging, machining, grinding. We pass along this information to users of Bethlehem tool steel—just one of many benefits that result. It's a continuous development program—unmatched in its scope!

Bethlehem makes all tool steels. In our modern mill depot we stock 23 grades of standard and special-purpose steels for quick delivery to our distributors and mill customers.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation.

Bethlehem ULTRASONIC TESTED **Tool Steel**

consider DIE CASTING when redesigning for LOWER COSTS

THE DIE CASTING PROCESS: Speed of production is the essence of the die casting process—the shortest distance between raw material and finished product; it is a precision, low-unit labor process, capable of producing direct from the raw material the most complex parts in nearly finished form at a single operation.

ZINC DIE CASTINGS: Zinc is the most adaptable metal for the die casting process and provides the best combination of physical and chemical properties. Zinc die castings are stable, strong, and can be cast to close tolerances; they are easily machined and a large variety of beautiful metallic and organic finishes can be readily applied to the castings.

Industry's recognition of these factors is indicated by the phenomenal growth of die casting as a production tool plus the fact that nearly 75% of all die castings by weight are made of zinc. **DIE CASTING** is the Process • **ZINC**, the Metal • **BUNKER HILL**, the Preferred Zinc

BUNKER HILL 99.99+% ZINC

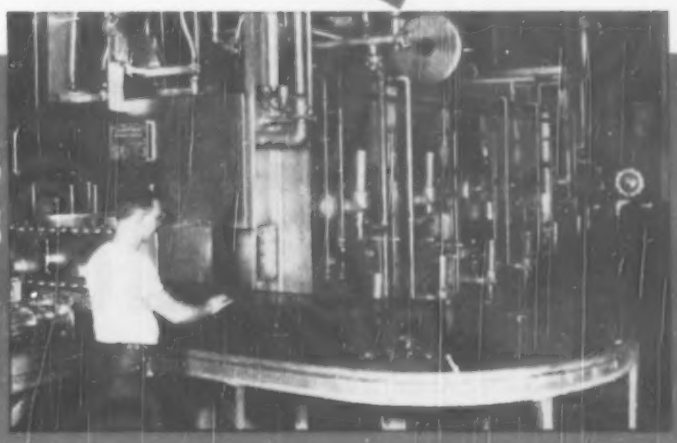
EASTERN SALES AGENTS ST. JOSEPH LEAD COMPANY 250 PARK AVENUE, NEW YORK 17
SALES OFFICE FOR PACIFIC COAST NORTHWEST LEAD COMPANY SEATTLE, WASHINGTON

ROLOCK

FABRICATED HEAT AND CORROSION RESISTANT ALLOYS

GAS CARBURIZING BASKETS

10 to 12 Months Life, 3 Shift Service



The Rolock fabricated baskets shown have handled with outstanding economies drive shaft parts through a Surface Combustion Continuous Gas Carburizing furnace in the plant of a large automotive manufacturer in Detroit. Repeated exposure to the embrittling, high temperature environment has proven these baskets.

A recent performance check conclusively demonstrates the advantages of fabricated construction for service of this nature.

1. *The baskets have a life of 10 to 12 months of 3-shift service in this embrittling atmosphere.*
2. *100 lb. live loads handled with ease in this 31 lb. basket...2½ to 1 work/alloy ratio, tray included!*
3. *Design assures thorough atmosphere circulation as well as quench oil circulation and complete drainage.*
4. *Uniform, high quality work attained from part to part, and load to load.*

Rolock fabricated heat treating equipment is cutting costs in leading plants through engineered-to-the-job construction which produces prolonged service life, increased furnace capacities with reduced dead weight, and improved product quality.

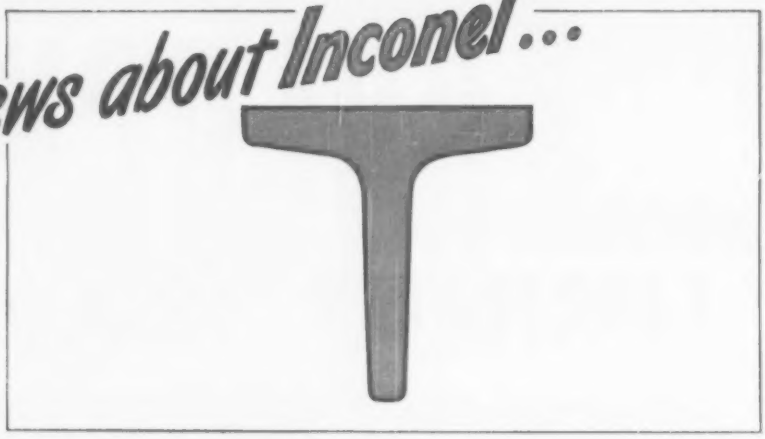
Call a Rolock engineer for our recommendations on reducing your heat-hour costs.

Offices in: PHILADELPHIA • CLEVELAND • DETROIT • HOUSTON • INDIANAPOLIS • CHICAGO • ST. LOUIS • LOS ANGELES • MINNEAPOLIS

ROLOCK INC. • 1222 KINGS HIGHWAY, FAIRFIELD, CONN.

JOB-ENGINEERED for better work Easier Operation, Lower Cost

More news about Inconel...



T-SECTIONS
AVAILABLE NOW

Designers and fabricators have been asking for them . . . and now they are here!

Inconel® T-Sections, 1½" x 1½" x ¼", are available for immediate delivery.

The new Inconel T-Sections were produced in answer to many requests from fabricators, industrial furnace builders, and plants doing heat-treating. Inconel T-Sections, together with Inconel angles, will simplify numerous design problems in the construction of furnaces and heat-treating fixtures.

Because of its outstanding performance record and excellent cost-to-service ratio, many of the nation's leading fabricators have adopted Inconel as a standard metal for high-temperature equipment. Highly resistant to high temperature and destructive furnace atmospheres, Inconel maintains good properties at temperatures up to 2200 F°. Welds in Inconel are as heat- and corrosion-resistant as Inconel itself.

If you would like full engineering information about Inconel or help with your metal-selection problems, write to our Technical Service Department.

Your nearest INCO distributor is prepared to fill your Inconel needs from stock.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

EMBLEM OF SERVICE INCO

INCONEL *. . . for long life at high temperatures*

ENGINEERING DIGEST OF NEW PRODUCTS

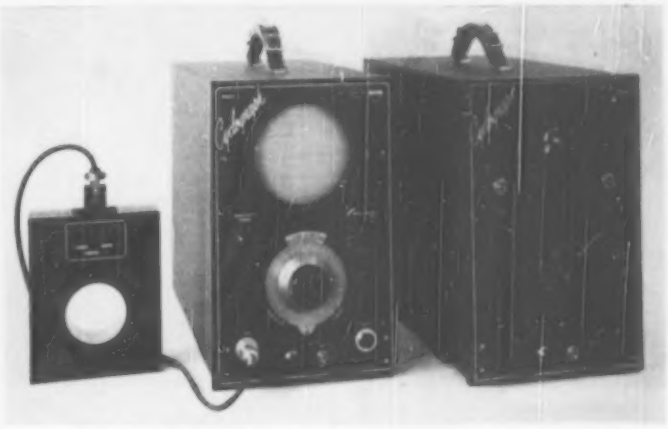
HIGH-SPEED AUTOMATIC METAL SORTER: The new automatic "Cyclograph" based on Dumont patents is announced by J. W. Dice Co. The Cyclograph affords high speed, nondestructive quality control and sorting of metal parts of any size by their metallurgical characteristics.

Operating on magnetic principles, it can rapidly sort by mixed analysis of the part, structure, hardness, case depth, brittleness, or almost any metallurgical difference.

Testing speeds of 1 to 5 parts per second can be attained when parts are sent through the test coil on a belt conveyer or by other fast feeding means.

The automatic cyclograph provides both "single level" and "two level" sorting. The instrument can be used to reject only parts giving a low Cyclograph reading or to reject both above and below an established acceptable range.

For further information circle No. 512 on literature request card on page 32B



STAINLESS TUBE TAKES SEVERE COLD FORMING: A new stainless steel which work hardens much slower than conventional chromium-nickel steels is now available in tubing form, for applications requiring severe deforming, bending, or upsetting. The new stainless tubing is made by The Carpenter Steel Co., Alloy Tube Div., and is known as Carpenter Stainless No. 10 tube.

Type analysis of the new material is carbon 0.08% max., chromium 16.0%, nickel 18.0%. Developed to overcome the manufacturing difficulties associated with the rapid work hardening of conventional 18-8 stainless steels, the new tube is recommended for all tubular parts requiring severe forming, bending, spinning, coining, extruding, and upsetting. It can be satisfactorily brazed or soldered after cold working. Among its applications are flexible hose, integral finned tube, heavy lapped Van Stone flanges with stub ends, spun end thermocouples, and electrical instruments. The slow rate of cold workability of No. 10 is shown by the following tensile strengths after a 50% reduction: Stainless No. 10—146,000 psi.; Stainless Type 305—165,000 psi.; Stainless Type 304—170,000 psi.; Stainless Type 302—190,000 psi. Carpenter Stainless No. 10 is particularly useful for parts that must remain nonmagnetic after severe cold working, since its permeability is approximately 1.002 after a 50% reduction with a field of 200 Oersteds, and about 1.018 after an 80% reduction.

Since the new tube is well adapted to spinning operations, it could be used successfully to fabricate such products as this high pressure container and dispenser. Before the advent of Stainless No. 10 tubing, it would have been extremely difficult to make the tank part of the unit, with closed ends.

The corrosion resistance of Stainless No. 10 is slightly better than Types 304 and 305. It resists a wide variety of organic and inorganic chemicals and foodstuffs. No. 10 resists nitric acid well and sulphuric acid moderately. It will not resist hydrochloric and other halogen acids.

Available sizes — round tubes are available in all sizes and standard gages up to 1⅝ in. o.d. and shapes whose equivalent round will not exceed 1⅝ in. o.d. Special rollings requiring at least 2000 lbs. would be required for larger sizes.

For further information circle No. 513 on literature request card on page 32B

UNIVERSAL TESTING MACHINES: With the introduction of a new electronic null system attachment, "L"-type Universal Testing Machines can now be provided with extra low test ranges by Tinius Olsen Testing Machine Co. This unit, which can be added to any "L" machine, is standard capacity up to 60,000 psi., and operates without the necessity of stopping the test while load change is being made. A 600,000-lb. machine with secondary range of 10,000 lb. has an "extra low" range of 1000 lb. in 2-lb. increments.

The electronic null system employed has but three moving parts, and receives signals from the developed hydraulic pressure in the cylinder of the machine, and electronically translates them into the rotary motion of the pointer. Accuracy in the "extra low" range is guaranteed within A.S.T.M. requirements.

For further information circle No. 514 on literature request card on page 32B

Tempilstiks®

The amazing Crayons that tell temperatures

A simple method of controlling temperatures in:

- **WELDING**
- **FLAME-CUTTING**
- **TEMPERING**
- **FORGING**
- **CASTING**
- **MOLDING**
- **DRAWING**
- **STRAIGHTENING**
- **HEAT-TREATING IN GENERAL**

Also available in pellet and liquid form

It's this simple: Select the Tempilstik® for the working temperature you want. Mark your workpiece with it. When the Tempilstik® mark melts, the specified temperature has been reached.

$2 each gives up to 2000 readings

Available in these temperatures (°F)

113	263	400	950	1500
125	275	450	1000	1550
138	288	500	1050	1600
150	300	550	1100	1650
163	313	600	1150	1700
175	325	650	1200	1750
188	338	700	1250	1800
200	350	750	1300	1850
213	363	800	1350	1900
225	375	850	1400	1950
238	388	900	1450	2000

FREE —Tempil® "Basic Guide to Ferrous Metallurgy" — 16¼" by 21" plastic-laminated wall chart in color. Send for sample pellets, stating temperature of interest to you.

GORDON SERVICE

CLAUD S. GORDON CO.

Specialists for 36 Years in the Heat Treating and Temperature Control Field

Dept. 15 • 3000 South Wallace St., Chicago 16, Ill
Dept. 15 • 2035 Hamilton Ave., Cleveland 14, Ohio

DEGREASER: The design of a new, large capacity Circo vapor-spray degreaser has just been announced by Circo Products Co. This new model, called the C-120, was designed for the transportation field and heavy industrial use. It has a vapor depth of 84 in., inside length of 96 in. and width of 60 in.

The C-120 Circo degreaser is available in either nickel clad, stainless

clad or zinc sprayed construction. Its nonflammable, nonexplosive solvent is heated by steam, gas or electricity, forming a blanket of vapor which is 84 in. deep. Ample heat input assures a cleaning capacity of 18,000 lb. per hour. An outside water jacket and inside water coils give double protection against vapor loss. Safe, economical operation is assured by a fully automatic control system.

According to Fenton Davison, vice-president, "'Circo-Solv', the solvent used, is absolutely harmless to all metals". He further stated that "depending on size, parts degreased by the Circo vapor and spray method can be removed absolutely clean and dry in 1 to 15 min."

For further information circle No. 515 on literature request card on page 32B

SEALED GAS BURNER: The latest addition to the McKee-Eclipse family of Walltite Burners is the new Series "PW" Piloted Walltite Burners offered by Eclipse Fuel Engineering Co. This is a sealed burner designed for gas-burning installations requiring instantaneous flame failure protection and constant pilot.

This combined protection is obtained by incorporating a McKee Blast Type Constant Burning Pilot located in a low-velocity zone, to insure instantaneous ignition at all rates of firing—and an electrode for Electronic Flame Failure protection. The electrode is at the junction of the pilot flame and main burner stream in order to assure safe operation.

Features of the new "PW" series are high-input efficiency resulting from Venturi design, better control of Air-Gas ratio, and placing of the burner steel entirely outside the furnace shell. This location is designed to provide longer life for the burner by exposing it less to furnace temperatures, and thus eliminates much of the heat which tends to deteriorate the burner tip. Burner and wall mounting are one casting. The new Piloted Walltite Burners are particularly recommended where temperatures are low or on furnaces where burners are in a "difficult-to-light" location.

For further information circle No. 516 on literature request card on page 32B

HIGH SPEED AND HEATING FURNACES: Outstanding for their productive capacity and compact construction are these High Speed End Heating Furnaces recently built by Surface Combustion Corp. for a leading manufacturer of oil field equipment.

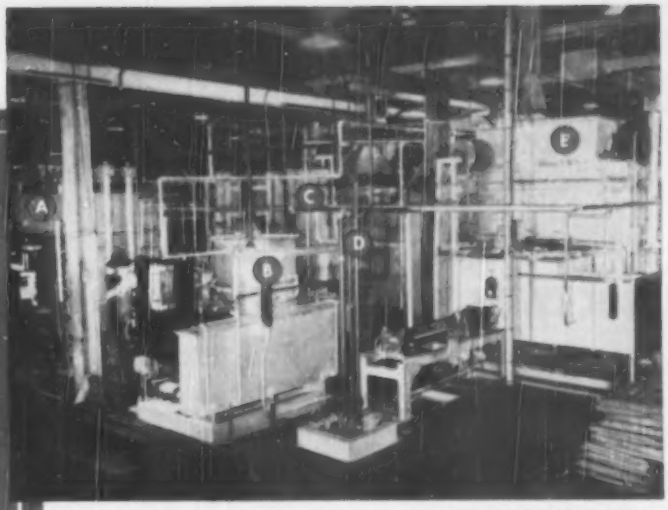
These furnaces will be used for heating the ends of steel oil well

sucker rods — ⅝ to 1 in. in diameter — for upsetting the ends. They will operate on natural gas and have a designed capacity of 180 1-in. diameter bars each per hr. Seven bars are in process in the furnace at any given time.

To meet the production line requirements, the furnaces were designed with a maximum width of 21 in. Each furnace has a heating zone 15 in. wide and a 1,210,000 B.t.u. per hour heat input.

For further information circle No. 517 on literature request card on page 32B

How Close Cooperation Between Alloy Foundry And Furnace Maker resulted in SUPERIOR WORK-HANDLING EQUIPMENT



Giant Lithium vapor atmosphere unit, built by The Lithium Company, Newark, N. J. (A) gas cracking chamber; (B) Lithium generator; (C) hardening furnace; (D) degreasing equipment; (E) draw furnace. These components, together with quenching equipment, and loading, conveying and unloading mechanisms, are integrated into a unit whose entire operation can be push-button controlled by a single operator. Hardening furnace atmosphere is of the Lithium endothermic type, affording carbon control plus Lithium anti-oxide coating. Draw furnace atmosphere is of the Lithium exothermic type, affording scale-free Lithium protective coating. Pickling and parkerizing are eliminated, and heat-treated work can be stack piled without fear of rusting.

In devising a method for handling different size cylindrical CO_2 containers during heat-treating cycles in this giant, automatic, Lithium atmosphere furnace installation, two important requirements had to be met:

1. furnace fixtures had to be simple — to permit quick loading and unloading;
2. fixtures had to assure each container receiving uniform heat treatment over its entire surface.

With a combined tray-and-fixture assembly of outstanding efficiency and simplicity of design, Driver-Harris successfully met the problem. Each tray, cast from high heat-resistant D-H Chromax*, accommodates four vertical, hot-rolled Nichrome* rods which, in turn, support a horizontal grid composed of heavy gauge Nichrome wire, and a horizontal Nichrome wire woven screen. Both grid and screen can be adjusted to any height on the rods. The grid holds the CO_2 container vertical, and the screen prevents it from floating off during quenching (and corner of screen also triggers mechanism which automatically fixes quench level, so that oil does not enter container). A second screen, for supporting small diameter containers, is laid on the tray itself.

Containers from 2" to 8" in diameter, and from 8" to 25" in length, are easily handled by this versatile fixture, by simply selecting grids with collars accommodating the containers involved.

Here is a striking example of how Driver-Harris, by a combination of facilities and materials furnished within its own organization, can meet the toughest specifications for heat-treating equipment ... and an outstanding example of cooperation between the alloy foundry and furnace maker.

Whatever your heat-treating problem, therefore, send your specifications to us. We'll put 50 years of experience at your disposal ... supply the alloy best suited to your needs.

Work-handling fixture designed by Driver-Harris. Trays interlock, by means of dovetails. Up to 24 trays can be under heat at one time, concurrently with 12 being returned to the starting point for reloading. Operating at temperatures as high as 1650°F., this equipment gives top-level performance at extremely low heat-hour cost. Cast Chromax rails assure long, economical service in the hardening furnace (1650°F.), and rails cast from D-H Cimet* do likewise in the draw furnace (1200°F.).

FIFTIETH ANNIVERSARY — SPECIAL PURPOSE ALLOYS SINCE 1900 — D/H — TRADE MARK REG. U. S. PAT. OFF.

Nichrome, Chromax and Cimet are manufactured only by

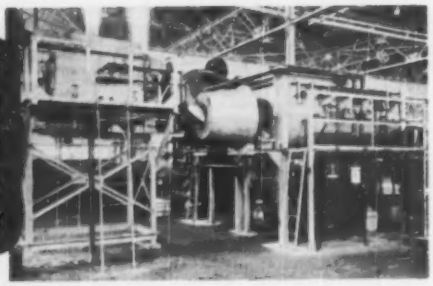
Driver-Harris Company

HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco

*T. M. Reg. U. S. Pat. Off.

For Continuous Automatic Heating with Control of Heating Rate and Product Uniformity



ROCKWELL *Revolving Retort* FURNACES

Offer Many Advantages

For annealing, hardening and drawing small ferrous or non-ferrous metal parts which may be slowly tumbled during slow helical progression through the retort, this Rockwell Furnace exposes all pieces at the same heating rate and time under controlled conditions of temperature and atmosphere.

Work may be bulk fed from washing machines or hoppers and discharged into cooling, pickling, cleaning or other processing equipment, without manual handling — in minimum space and without interfering with other operations.

Furnaces may be gas- or oil-fired or electric. Available in 4 standard sizes for 300, 800, 1500 and 1800 lbs. of metal heated per hour. Special sizes to order. Write for Bulletin 424R.

ROCKWELL ALSO BUILDS • *Coil winding machines, reels and spools; pickling, brushing, cleaning, washing, finishing, drying and handling equipment; ovens and dryers; special fabrications; non-ferrous rod mills.*

ROCKWELL SINCE 1888 BUILT

FURNACES · OVENS · SPECIAL MACHINERY

W. S. ROCKWELL COMPANY

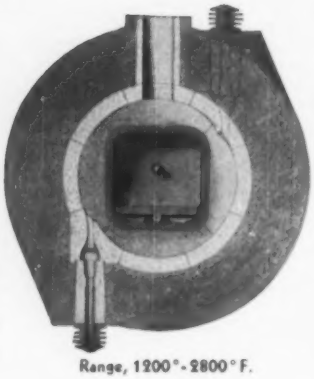
204 ELIOT STREET • FAIRFIELD, CONN.

The Inside Story!

On the
DELAWARE
Controlled Atmosphere
FURNACE

• • • •

The complete story of the tangential firing principle and other distinctive features of the Delaware Controlled Atmosphere furnace is told in informative bulletin F-1.



Range, 1200°-2800°F.

• • • •

Learn the facts
of Modern Heat Treating

Send for your copy today!

DELAWARE TOOL STEEL CORP.

WILMINGTON • DELAWARE

NEW PRODUCTS

CORE BAKING TUNNEL: Now available to the foundry industry is the new Model M-7200 Thermonic Electronic Core Baking Tunnel, developed by the Induction Heating Corp.

The M-7200 which bakes cores evenly throughout, with an average baking cycle of only a few minutes, has a capacity of 4 tons of cores per hour. The unit is capable of baking cores up to 60 in. wide with a maximum combined height of core and core plate of 20 in. The approximate over-all dimensions of the tunnel are 8 ft. wide, 8 ft. high and 25 ft. long. A conveyer speed is adjustable from 0 to approximately 6 ft. per min.

Green cores may be loaded in the core room, directly onto the Thermonic tunnel conveyer, eliminating all the racking and much of the handling of the cores in the green state.

After the baking cycle, the core plate emerging from the tunnel may go directly onto the inspection table. There is no cooling period involved and the cores are ready for immediate inspection and use. The conventional method of loading and unloading large storage racks is entirely avoided.

For further information circle No. 518 on literature request card on page 32B

REMOVING WATER FROM METAL ARTICLES: Drying finished metal products has always been a problem to the manufacturer and plater. The old stand-by, sawdust, often contaminates the work, especially in recessed sections. Warm air drying often results in staining, and even hot water may leave residual salts after evaporation, showing as stains or white spots.

For that reason, a water-remover called Aqua-Off has been developed by the Chemclean Products Corp. to remove water from plated or unplated work, such as pieces that have been polished, cleaned in alkali cleaner and then rinsed in hot or cold water prior to storing or lacquering. For a dry surface, free of water stains, the work is immersed in the Aqua-Off after the final hot water rinse, gently agitated, and then removed. Water is displaced and falls to the bottom of container, leaving the work free from water but covered with a slight film from the Aqua-Off, which is readily removable by holding it in the vapors in a degreaser.

For further information circle No. 519 on literature request card on page 32B

The HOUGHTON LINE NEWS

VOL. 18, NO. 3 JULY, 1950

...the "near editor's" viewpoint

"Quickies" from a quick trip to France:

Seems to be no immediate prospect of a Communist government in France. "Commies" are a noisy minority, but the average Frenchman is too much of an individualist to be a Communist.

Apparently there is no picketing during strikes in France.

Fashion note: Daytime skirts are short and very tight, belted in at the waist until one wonders how the girls breathe.

Plant of Societe des Produits Houghton in Paris, destroyed by spectacular fire which made U.S. newsreels in 1948, now rebuilt.

CHAIRMAN OF THE BOARD.

Tanks to Houghto-Draw

Drawing of gas tank half sections in one simultaneous operation is being done by a large steel processor with the aid of a mixture of two *Houghto-Draw* compounds.

A 38½" blank of steel .105" thick is drawn into a shape 24" deep, eliminating four to six operations formerly required. The complete cycle, including automatic loading and unloading, takes only 24 seconds.

A mixture of 5 ounces each of Houghto-Draw 356 and 357 to the gallon of water at 130° F. did the trick. Discs were coated, dried and drawn without squealing or chatter, which had been a problem. After drawing 50 sections satisfactorily, they tried the previous compound, but the squeal was again heard. It disappeared when they returned to Houghto-Draw.

The Houghton technical man in your section will recommend, after review and trial, the best Houghto-Draw for your drawing need. And he'll stay on the job until he makes it work. Want to see him?

Why Rectify?

So simple a part as a bolt for a lift truck may present a heat treating problem. One manufacturer had heated bolts in salt, but had trouble keeping the bath in balance. He had rectified the bath three times a day, and desludged it each day. Then he switched to Houghton's *Liquid Heat 1145*, with a quench in our treated quenching oil. Results: time saved on rectification, hardness increased, no decarburized work.

No Mystery About Salt, But—

The day has passed when the composition of heat treating salts was a mystery. Nearly every metallurgist knows, or can learn from standard reference books, how to formulate salt mixtures for various heat treatments of steel.

Why, then, should they not make up their own mixtures from basic chemicals and save money? Or, why shouldn't they buy on lowest price per pound? Sounds plausible, but it's not being done, even by the largest users. And there are good reasons why not.

In the first place, operating difficulties require more knowledge than a man equipped with a price list and chart of salt melting points can hope to have.

Most salt mixtures are based on some thirty nitrates, nitrites, carbonates, chlorides, fluorides, cyanides, etc. These materials are obtained from a limited number of sources known to most metallurgists.

But the strict control exercised over incoming shipments by Houghton, based on many years of experience, sets up a safeguard against possible impurities in the salts. Each lot is sampled and analyzed in our Laboratory.

Impurities even to the third decimal point may affect the service a chemical gives in heat treating. Even a C. P. (Chemically Pure) salt may contain a prescribed maximum of such impurities. Such contaminants as chlorides in a nitrate bath or sulphates in a hardening salt would tend to attack the work or pot after continued operation.

Rectification of a salt bath isn't always easy. It takes time and experience. Our own practice has been to make such baths as nearly self-rectifying as possible by including, wherever we can, a rectifying element in the salt mixture itself which prevents decarburization.

Proper mixing of the ingredients is most essential, as the formula is set up for an eutectic mixture; if improperly compounded, the batch may vary and cause trouble when the salts are put under heat.

There's still another very sound reason for buying salts from an experienced, reputable supplier. That is *service*.

The Houghton Man who calls on you is likely to be a specialist himself, in heat treating and in metal working, all the way from iron and steel to the finished, heat-treated, machined piece. He is not a salt specialist alone; often he is an engineering graduate with long field experience. Behind him are metallurgical engineers ready to help him and his customers.

Those technicians look further than the salt if the user isn't getting the results he wants. They may go back to furnace design, or to steel analysis, or shape of part—or look ahead to the quench or draw or final cleaning.

While metallurgy itself has become a pretty exact science, there is still a certain amount of experimentation necessary, and plant metallurgists are quick to admit that counsel and advice from our trained field specialists and research staff men have helped them out of many difficulties.

So there's the purity of salts, the know-how in manufacturing them, and the ability to step into a plant and make them perform right — three good reasons why metal men prefer to buy salts from Houghton. Maybe you can buy salt at a lower price per pound, but the service is worth the small extra amount it may cost. Think it over!

Double Tool Life at ½ the Oil Cost

Which would you use — a cutting fluid which costs 46 cents per gallon, and which permitted 21,600 pieces between tool grinds, or a fluid which cost 16 cents per gallon, mixed with water, that so lubricated the tools as to enable 54,000 pieces to be machined without a tool grind?

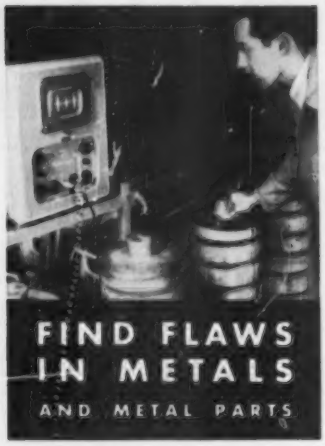
The answer is obvious. You'd do what that company did — standardize on *Antisep All-Purpose Base*, miscible with water, yet having a higher film strength than straight oil. Better look into this base, which will do 90% of your cutting jobs, and do them better.

Can You Use This Helpful Data?

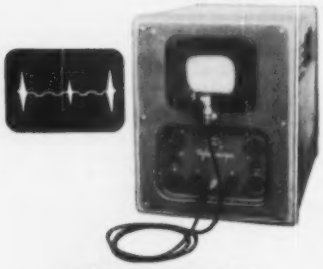
Check the items you'd like to receive, and attach this slip to your letterhead, mailing to address below. The material will be sent free, without obligation.

1. Liquid Salt Bath Catalog—32 pages of description and working ranges of Houghton salts for heat treating.
2. "All-Star" Line-up of Rust Preventives—8 page booklet listing the Rust Veto "Winning Eleven."
3. Hydraulic Oil technical bulletin; setting forth the merits of treated Hydro-Drive Oils, with test data.
4. Product Data Sheet on Houghto-Draw 357 for wire, rod, bar and tube drawing.
5. Houghto-Clean 220 Data Sheet, describing emulsion-type cleaner for metals.

E. F. HOUGHTON & CO.
303 W. LEHIGH AVENUE
PHILADELPHIA 33, PA.



Swiftly
Surely
Economically



SPERRY
Ultrasonic
REFLECTOSCOPE

The Sperry Ultrasonic REFLECTOSCOPE finds voids, inclusions, fatigue cracks and other discontinuities in metals and metal parts. The REFLECTOSCOPE transmits pulsed vibrations into one end of the metal to be tested. These vibrations are reflected from the opposite end, or from any discontinuity, and the condition of the metal is shown instantaneously on the ultrasonic screen. The REFLECTOSCOPE is the quickest, most economical means of determining soundness of raw materials before and after processing. Investigate its benefits for your application today.

ASK ABOUT OUR LEASE AND COMMERCIAL TESTING SERVICES

Sperry

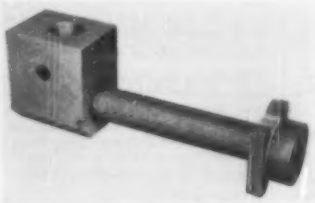
SPERRY PRODUCTS, INC.
Danbury, Connecticut
PHONE: Danbury 8-3581

ALSO MANUFACTURERS OF HYDRAULIC CONTROLS AND SELF-SEALING COUPLINGS

ENGINEERING DIGEST OF NEW PRODUCTS

"KARBATE" CIRCULATING STEAM JETS: The Series FM-1A "Karbate" Brand impervious graphite circulating steam jet is announced by National Carbon Div., Union Carbide and Carbon Corp.

The jet itself is made entirely of "Karbate" impervious graphite, while the riser is a standard "Karbate" impervious graphite pipe fitted with a Neoprene "Flexlock" gasket at the submerged connection to the jet and a Type V flange connection at the other end, permitting simple connection to steam lines. This construction assures complete resistance to the corrosive action of the liquid being heated. They are available in two sizes, Size 2 and Size 4, with riser assemblies up to 9 ft., 3¾ in. in height, and supplement the two types of "Karbate" impervious graphite heat exchangers which are used for indirect heating of open tanks.



These circulating steam jets are particularly adapted to the heating of liquids in tanks where agitation, good circulation and low cost are requisites and where dilution of the solution is not harmful. They withstand the action of practically all corrosive liquids, including sulphuric acid, hydrochloric acid and nitric-hydrofluoric acid mixtures and are recommended for heating acid solutions in ore digesters, for cooking, and for many other operations performed by injection of steam. They can be subjected to severe thermal shock without cracking, chipping or spalling.

For further information circle No. 520 on literature request card on page 32B

MOLTEN STEEL THERMOCOUPLE: A lighter, faster and easier-to-use immersion thermocouple for measuring temperature of molten steel is announced by Brown Instruments Div. of Minneapolis-Honeywell Regulator Co.

The thermocouple, about one-half the weight of previous designs, will be supplied in two forms. One will have a 90° bend for electric furnaces, the other a 60° bend for easy insertion through openhearth wickets. Both forms have 6 ft. handles. The immersion end of the thermocouple, excepting the immersion tip, is covered with a refractory compound.

The new design, developed by the Republic Steel Corp., will be built under license by Honeywell's Brown division at Philadelphia.

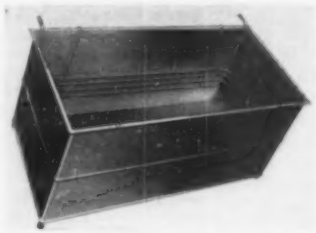
The complete assembly, handle and immersion end, is about 11 ft. long and weighs approximately 40 lbs. To make it more rigid, and to protect the thermocouple wires, the handle is built of two-layer seamless tubing having an outer covering of refractory sleeving. The platinum thermocouple wires extend from the extension wire at the handle, through the tubing and to the thermocouple tip.

Brown is offering the Republic immersion thermocouple assembly at $220; delivery, about eight weeks.

For further information circle No. 521 on literature request card on page 32B

FOR ANODIZING ALUMINUM PROCESS: A newly developed tank for anodizing aluminum, primarily constructed to give continuous service for three years under normal operations, is announced by the F. H. Langsenkamp Co.

Designed especially for the anodizing process, the tank is reinforced within itself — (the welds at all four corners overlapping) thereby keeping buckling to a minimum, preventing galvanic action, and lengthening the life of the tank.



Available in all sizes, in stainless steel, aluminum, or copper, the tank effects valuable savings in operation, time, and production. A lead lining is available when desired.

Langsenkamp Co. also features a Weldless 16-Tumbler Rack designed for use in anodizing tanks measuring 18 in. wide by 42 in. deep. Use of the racks eliminates poor conductivity, increasing rack service 50%. Racks are fabricated from ⅜ x ¾ in. 24 ST aluminum.

For further information circle No. 522 on literature request card on page 32B

WE MAKE ALL ANALYSES OF

Stainless, Heat Resisting and Special Purpose, Arc Welding Electrodes

(The Tough Ones as well as the Easy Ones)

★

SPECIAL SERVICE AVAILABLE

WIRES IN COILS FOR AUTOMATIC OR SPRING
ALSO STRAIGHT LENGTHS
SIZES IN ALL ANALYSES
1/16" to 1/4" Diameters

ROUND EDGE FLATS
½" wide and narrower
Ratio 10 to 1

COLD DRAWING FACILITIES
3/8" to 1/16" Diameters
Annealing Capacity—6 ft. Diameter, 6 ft. High
up to 2300 degrees
weight up to 5000 lbs.

PICKLING OF ALL ALLOYS
Tanks 4 ft. Wide, 8 ft. Long, 5 ft. Deep

WIRE IN COILS
FOR AUTOMATIC WELDING OR SPRINGS

★

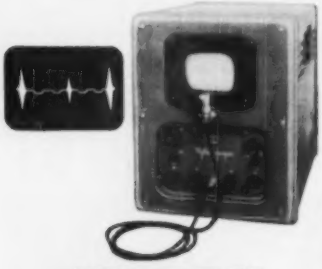
MAURATH, Inc.

Northfield and North Miles Road
NORTH RANDALL, OHIO
Phone: Montrose 1220-1-2
Mailing Address: P. O. Box 817, Warrensville Branch,
Cleveland 22, O.

FIND FLAWS IN METALS

AND METAL PARTS

Swiftly Surely Economically



SPERRY

Ultrasonic

REFLECTOSCOPE

The Sperry Ultrasonic REFLECTOSCOPE finds voids, inclusions, fatigue cracks and other discontinuities in metals and metal parts. The REFLECTOSCOPE transmits pulsed vibrations into one end of the metal to be tested. These vibrations are reflected from the opposite end, or from any discontinuity, and the condition of the metal is shown instantaneously on the ultrasonic screen. The REFLECTOSCOPE is the quickest, most economical means of determining soundness of raw materials before and after processing. Investigate its benefits for your application today.

ASK ABOUT OUR LEASE AND COMMERCIAL TESTING SERVICES

Sperry

SPERRY PRODUCTS, INC.

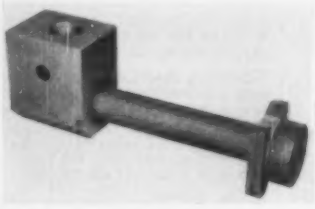
Danbury, Connecticut

PHONE: Danbury 8-3581

ALSO MANUFACTURERS OF HYDRAULIC CONTROLS AND SELF-SEALING COUPLINGS

"KARBATE" CIRCULATING STEAM JETS: The Series FM-1A "Karbate" Brand impervious graphite circulating steam jet is announced by National Carbon Div., Union Carbide and Carbon Corp.

The jet itself is made entirely of "Karbate" impervious graphite, while the riser is a standard "Karbate" impervious graphite pipe fitted with a Neoprene "Flexlock" gasket at the submerged connection to the jet and a Type V flange connection at the other end, permitting simple connection to steam lines. This construction assures complete resistance to the corrosive action of the liquid being heated. They are available in two sizes, Size 2 and Size 4, with riser assemblies up to 9 ft., 3⅝ in. in height, and supplement the two types of "Karbate" impervious graphite heat exchangers which are used for indirect heating of open tanks.



These circulating steam jets are particularly adapted to the heating of liquids in tanks where agitation, good circulation and low cost are requisites and where dilution of the solution is not harmful. They withstand the action of practically all corrosive liquids, including sulphuric acid, hydrochloric acid and nitric-hydrofluoric acid mixtures and are recommended for heating acid solutions in ore digesters, for cooking, and for many other operations performed by injection of steam. They can be subjected to severe thermal shock without cracking, chipping or spalling.

For further information circle No. 520 on literature request card on page 32B

MOLTEN STEEL THERMOCOUPLE: A lighter, faster and easier-to-use immersion thermocouple for measuring temperature of molten steel is announced by Brown Instruments Div. of Minneapolis-Honeywell Regulator Co.

The thermocouple, about one-half the weight of previous designs, will be supplied in two forms. One will have a 90° bend for electric furnaces, the other a 60° bend for easy insertion through openhearth wickets. Both forms have 6 ft. handles. The immersion end of the thermocouple, excepting the immersion tip, is covered with a refractory compound.

The new design, developed by the Republic Steel Corp., will be built under license by Honeywell's Brown division at Philadelphia.

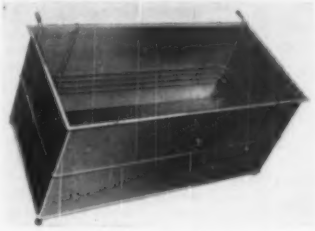
The complete assembly, handle and immersion end, is about 11 ft. long and weighs approximately 40 lbs. To make it more rigid, and to protect the thermocouple wires, the handle is built of two-layer seamless tubing having an outer covering of refractory sleeving. The platinum thermocouple wires extend from the extension wire at the handle, through the tubing and to the thermocouple tip.

Brown is offering the Republic immersion thermocouple assembly at $220; delivery, about eight weeks.

For further information circle No. 521 on literature request card on page 32B

FOR ANODIZING ALUMINUM PROCESS: A newly developed tank for anodizing aluminum, primarily constructed to give continuous service for three years under normal operations, is announced by the F. H. Langsenkamp Co.

Designed especially for the anodizing process, the tank is reinforced within itself — (the welds at all four corners overlapping) thereby keeping buckling to a minimum, preventing galvanic action, and lengthening the life of the tank.



Available in all sizes, in stainless steel, aluminum, or copper, the tank effects valuable savings in operation, time, and production. A lead lining is available when desired.

Langsenkamp Co. also features a Weldless 16-Tumbler Rack designed for use in anodizing tanks measuring 18 in. wide by 42 in. deep. Use of the racks eliminates poor conductivity, increasing rack service 50%. Racks are fabricated from ⅜ x ⅝ in. 24 ST aluminum.

For further information circle No. 522 on literature request card on page 32B

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

523. Abrasive

4-page bulletin on Black Beauty, the non-metallic, silica-free blast grit. Describes many advantages of this sharp, fast-cutting abrasive, including corrosion resistance, free-flowing action, and longer life. *American Wheelabrator & Equipment Co.*

524. Alloy, Aluminum

Bulletin "Almag 35" discusses the physical properties, machinability, resistance to corrosion and applications of this aluminum-magnesium alloy. *William F. Jobbins, Inc.*

525. Alloy Handbook

New pocket-size Alloy Handbook. It's a mine of nonferrous alloy information — and it's yours for the asking. *Riverside Metal Co.*

526. Alloys

Bulletin 4729-G discusses properties of special alloys for industrial use in resisting corrosion, high temperatures and abrasion. *Duraloy Co.*

527. Alloys

New catalog, "Electromet Ferro-Alloys and Metals", lists over 50 metals and alloys and describes unique technical service offered to the metal industries. *Electro Metallurgical Div.*

528. Alloys, Fabricated

New catalog is available, showing cost-cutting fabricated heat treating equipment for higher pay loads and better quality. *Rolock, Inc.*

529. Alloys, Low-Melting

Bulletin 14-6-49 outlines characteristics of Cerro alloys and lists physical properties as well as many and varied applications of these bismuth alloys that melt at low temperatures (440 to 1170°F) for the various compositions. *Cerro DePasco Copper Corp.*

530. Alloys, Nickel

Technical bulletin, "Cast 16% Cr – 35% Ni Alloys", completely illustrates heat, corrosion and abrasive-resistant cast alloys. *Electro Alloys Div.*

531. Alloys, Nickel

New technical bulletin T-6 discusses resistance of nickel and its alloys to corrosion by caustic alkalies. *International Nickel Co.*

532. Aluminum

Copy of "Alcoa Aluminum Impact Extrusions" will be sent on letterhead request, giving full information on impact extrusion process and service. Shows whole range of shapes for engineering. *Aluminum Co. of America*

533. Aluminum Finish

Iridite Al-Coat, new, clear protective coating for mill or buffed aluminum surfaces. Can be applied with one solution, by spray, brush or dip, in 10 seconds. Provides lasting, corrosion-resistant final finish or paint base for aluminum surfaces. Free samples and full information sent on request. *Allied Research Products, Inc.*

534. Blast Cleaning

There is a Pangborn rotoblast table, barrel, or table-room designed to bring you amazing savings. Write for bulletin 214. *Pangborn Corp.*

535. Castings

"A report on Precision" is an 8-page reprint of a recent article on the making and inspection of bronze aircraft engine parts. It also includes diagrams and colored illustrations of methods used in casting and machining such parts to insure dimensional accuracy. *American Non-Gran Bronze Co.*

536. Castings

Very attractive, well-illustrated booklet on "Modern Metallurgy for the Industrial User of Iron and Steel Castings". *Hunt-Spiller Mfg. Corp.*

537. Cleaning, Electrolytic

New booklet, "An Introduction to Electrolytic Cleaning", contains general information on this process and explains simply the phenomena taking place during both direct and reverse current cleaning, and the advantages of each. *Dullon Co.*

538. Cleaning Machine

Carbo-cleaner, the most compact, lowest priced carburizing-compound-cleaning machine on the market. Write for further details. *Tourner Engineering Co.*

539. Control Cabinets

New 16-page catalog contains over 40 illustrations plus descriptions of custom-built sheet metal electrical enclosures and control panels. *Kirk & Blum Mfg. Co.*

540. Control Devices

New 64-page catalog 8303 illustrates over 100 different industrial control devices for temperature, flow, pressure, liquid level and humidity. *Brown Instrument Co.*

541. Control Instruments

Booklet CAB-1 contains description of new "Cabinet Series" control panels with suggestions for combining auxiliary equipment. *Wheelco Instruments Co.*

542. Copper Alloys

28-page booklet entitled "Copper and Copper Alloys Specifications Index". Section 1 lists most generally used alloys together with all applicable specifications. Section 2 lists specifications in numerical order with brief description of materials covered. *American Brass Co.*

543. Copper Sheets

New 23-page booklet, the product of a ten-year program of design developments and tests combined with field investigations, contains complete, detailed specifications for all types of sheet metal installations employing copper. *Revere Copper & Brass, Inc.*

544. Electropolishing

Attractive photo-illustrated 14-page booklet gives complete story of American electropolishing, including composition, equipment, and various applications of this valuable process for bright polishing of both nickel-chrome and plain chrome steels. *American Steel & Wire Co.*

545. Finishing

Special zinc phosphate coating chemicals provide excellent surfaces for paint-bonding, rust-proofing and drawing. *American Chemical Paint Co.*

546. Finishing

New 36-page bulletin entitled "Step Up Production" contains case histories, examples and technical data on grinding and polishing with abrasive belts. *Minnesota Mining & Mfg. Co.*

547. Fittings, Stainless Steel

New stainless steel welding fittings price list (52W) contains latest prices covering a variety of fittings such as elbows, return bends, stub ends, tees, etc., in types 304, 316 and 347 stainless steel. *Cooper Alloy Foundry Co.*

548. Free-Machining Bar Steel

Reprint of article entitled "La-Led, A New Free-Machining Bar Steel", by Glenn D. Bayer, metallurgist at LaSalle Steel, discusses the advantages and characteristics of the new steel. *LaSalle Steel Co.*

549. Furnace

Bulletin SC-147 describes new rotary retort-controlled atmosphere furnace for fully automatic high production heat treatments including gas carburizing, dry cyaniding, homogeneous carburizing and cleaning hardening. Also equipped with internal screw-thread for smooth, even heating of small metal parts. *Surface Combustion Corp.*

550. Furnace Atmosphere

Bulletin F-1 gives full description of versatile, controlled atmosphere furnace for all steels from high carbon to high speed in range 1200-2800° F. *Delaware Tool Steel Corp.*

551. Furnaces

Bulletin B-32 illustrates and discusses typical installation of fuel-fired and electric heat treating furnaces and atmosphere equipment. *Drever Co.*

552. Furnaces

New bulletin on Malleable Iron Annealing Furnaces contains photographic description and sectional drawings of this furnace, and also describes the low-hydrogen gas generator for controlled-atmosphere malleable annealing. *Holcraft & Co.*

553. Furnaces

Bulletin T-1420 illustrates and describes Lindberg LI-25 induction heating unit. A ruggedly constructed vacuum-tube type of unit for hard working production-line jobs. Ideal for hardening, brazing and soldering, annealing and stress relieving, hot forming and light forging, shrink fitting and other induction heating applications. *Lindberg Engineering Co.*

554. Furnaces, Combustion, Tube

For full information on combustion tube furnaces with exclusive feature of multiple heating units readily replaceable, write today for bulletin 1236. *Hevi Duty Electric Co.*

555. Gas Generator

Bulletin 1-11 describes how new inert gas generator Model 1 M1HE, rated at 1000 c.f.h., obtains the same analysis of inert gas, regardless of demand. Fully automatic, it gives accurate proportioning and assures precise analysis over full operating range. Ratio control adjusts for manufactured, natural, propane, butane or refinery gases. *C. M. Kemp Mfg. Co.*

556. Gray Iron

Revised summary of Gray Iron specifications available in 4-page bulletin containing a resume of fourteen separate sets of gray iron specifications including a change in ASTM A-159-47 to ASTM A-159-49T and the addition of two new specifications covering automotive irons 113 and 114. *Gray Iron Founders' Society.*

557. Hardness Testers

Bulletin DH-114 contains full information on Tukon hardness testers for use in research and industrial testing of metallic and nonmetallic materials. Also included is bulletin DH-7, giving experiences in various fields. *Wilson Mechanical Instrument Co.*

558. Heat Treating

Pocket-sized bulletin, "Furnace Treatment of Republic Union Cold Drawn Steels", briefly discusses the various types of modern furnaces used in heat treating carbon and stainless bar steels. Also outlines advantages to the customer of different processes. *Republic Steel Corp.*

[• If mailed from countries outside the United States, proper amount of postage stamps must be affixed for returning card]

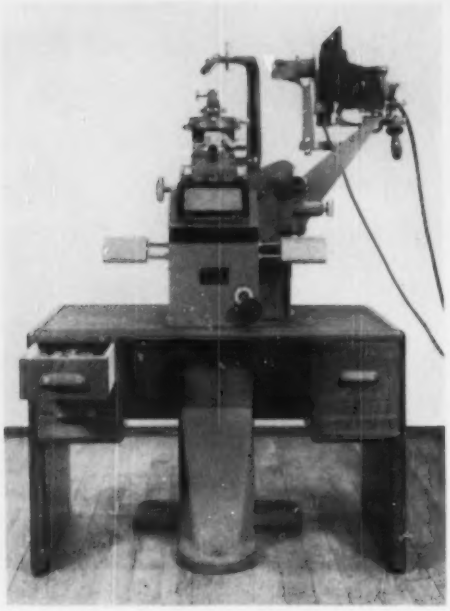
FIRST CLASS
PERMIT No. 1595
(Sec. 34.9 P.L. & R.)
Cleveland, Ohio

BUSINESS REPLY CARD
No Postage Stamp Necessary If Mailed In the United States

4c POSTAGE WILL BE PAID BY —

METAL PROGRESS
7301 Euclid Avenue
CLEVELAND 3, OHIO

The VICKERS



The PERFECT PHOTOMICROGRAPHIC INSTRUMENT

COMPLETELY VERSATILE . . . .

Range of magnification 3X to 4400X, incident or transmitted light. Dark ground and polarized light examinations of opaque or translucent substances. Convertible in 30 seconds to macro work with accessories supplied. Two light sources supplied for instantaneous changeover. Objectives of any make can be used.

FASTER AND MORE CONVENIENT IN USE . . . .

Users have photographed more than 120 different specimens a day. Camera length variable between 16 and 36 inches without movement of plateholder or any external part. There are no remote controls. Magnetic centering mounts for rapid changing of objectives.

NEW, ADVANCED DESIGN AND CONSTRUCTION . . . .

Immunity from vibration. Microscope head of heavy cast brass. Extremely robust. Stage will take specimens up to 50 pounds in weight. Precision of the highest order in every detail. Occupies very little floor space (28" x 30"). Supplied with fitted cabinet.

Catalogs Available on Request:

VICKERS PROJECTION MICROSCOPE

COOKE BENCH-TYPE METALLURGICAL MICROSCOPES

COOKE MICROHARDNESS UNIT

COOKE INCIDENT LIGHT PHASE CONTRAST

SCHENCK FATIGUE TESTING MACHINES

The R. Y. FERNER COMPANY

110 Pleasant Street

Boston 48 (Mal. Sta.), Mass.

. . . when you use "NATIONAL" Graphite Stool Inserts

● *It is impossible for molten metal to stick to graphite under any conditions.* This means that an ingot cannot possibly stick to a graphite stool insert. If you are bothered with stickers, equip your stools with "National" graphite stool inserts.

Think of the savings!

No lost time in freeing stuck ingots. Keeps maintenance costs down. For complete information on "National" graphite stool inserts, write to National Carbon Division, Union Carbide and Carbon Corporation, Dept. MP.

The terms "National" and "Eveready" are registered trade-marks of

NATIONAL CARBON DIVISION
UNION CARBIDE AND CARBON CORPORATION
30 East 42nd Street, New York 17, N. Y.

District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

Foreign Department: New York, U. S. A.

MORE THAN DOUBLE THE USABLE LIGHT!

The biggest news since the invention of flashlights—the brand new leakproof "Eveready" No. 1050 flashlight battery—gives more than double the usable brilliant white light for critical uses than any other flashlight battery we have ever made. NO METAL CAN TO LEAK OR CORRODE.

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

559. Heat Treating

Pressed steel lightweight sheet alloy heat treating units furnished in any size, design or specification. Write for full information on this. *The Pressed Steel Co.*

560. Holders, Laboratory

24-page booklet, "Castaloy Laboratory Appliances", presents a complete line of holders, clamps, and supports for holding laboratory equipment and assemblies. *Fisher Scientific Co.*

561. Induction Heating

New bulletin entitled "Typical Results of TOCCO Induction Hardening and Heat Treating" discusses the process with many actual case histories. *Ohio Crankshaft Co.*

562. Infrared Recorders

Bulletin 33 entitled "Infrared Recording Spectrophotometer" describes unique construction and operation of these instruments for use in production and testing of organic compounds. Two types of infrared spectrometers, the single-beam and double-beam, provide maximum speed and accuracy in qualitative and quantitative analysis of specimens. *Baird Associates, Inc.*

563. Lithium

28-page booklet, "Lithium in Modern Industry", reviews and forecasts significant developments in Lithium chemistry since 1940. *Foote Mineral Co.*

564. Lubricants

Interesting facts on how shop operation can be more efficient and economical through the use of right lubricants described in "Metal Cutting Fluids". *Cities Service Oil Co.*

565. Lubrication of Hot Metals

New bulletin 426 describes how (DAG) colloidal graphite can solve your lubrication problems in hot metal forming operations. *Acheson Colloids Corp.*

566. Machine Design

Fundamentals of producing low-cost machine parts — design, material and treatment — are discussed in new 72-page "Three Keys to Satisfaction". *Climax Molybdenum Co.*

567. Magnesium Pickling

Bulletin DM113 entitled "Dow No. 15 Bright Pickle for Magnesium" discusses the solutions, materials and procedures used in successfully applying the treatment. *Dow Chemical Co.*

568. Metal Forming

12-page folder entitled "Marform. The New Metal Forming Process" explains extensively the new rubber pressure deep drawing method and its technical and economical advantages. *Hydropress, Inc.*

569. Microcasting

The microcast process is graphically described in this 16-page booklet. Many applications are shown, together with specifications and step by step explanation. *Microcast Div., Austenal Laboratories.*

570. Microscopes

Catalog D-1010 illustrates and describes new E series of microscopes for the most exacting research work. *Bausch & Lomb Optical Co.*

571. Oils, Cutting

For the right combination to suit your specific requirements, write for the booklet, "Cutting Fluids for Better Machining". *D. A. Stuart Oil Co.*

572. Oils, Cutting

A practical slide-rule-type calculator to help you maintain desired soluble oil concentrations and new bulletin containing information on Gulf Soluble Cutting Oils available on request. *Gulf Oil Corp.*

573. Oil Quenching

Catalog V-1146 gives detailed information on self-contained oil coolers, together with easy selection tables. *Bell & Gossett.*

574. Paint Primer

"Protecting Gas Holders" is the title of the latest in a series of booklets outlining the advantages of silica graphite paint in reducing yearly maintenance costs of gas holders. Also provides valuable data on protection of metal structures of all types. *Joseph Dixon Crucible Co.*

575. Photography

Book entitled "Functional Photography in Industry" describes processes and techniques applicable to a wide range of endeavor. *Eastman Kodak Co.*

576. Plating Generators

For electroplating, anodizing, electrocleaning or electropolishing in either large-scale or small operations, there's a Columbia M-G set available for you. Catalog MP-700 sent free on request. *Columbia Electric Mfg. Co.*

577. Polishing

New booklet on the Electro Polisher gives latest information on this highly improved polishing machine for the metallurgical laboratory. *Buehler, Ltd.*

578. Polishing

New booklet, "Polishing Cloth and Abrasives", furnishes first-hand description and classification of some of the most used but least described accessories in modern sample preparation. *Buehler, Ltd.*

579. Pressure Vessel Accessories

Valuable reference catalog 9-49 contains 60 pages of important information on pressure vessels, styles and types and other handbook material. Sent upon request on company letterhead. *Lenape Hydraulic Pressing & Forging Co.*

580. Pyrometer

Catalog No. 80 illustrates and describes the Pyro Optical Pyrometer for quick, accurate temperature readings on minute spots, fast-moving objects and small streams in a temperature range from 1400°F to 7500°F. *The Pyrometer Instrument Co.*

581. Refractories

Revised bulletin entitled "Lumnite Refractory Concrete" discusses latest available information on refractories and heat-resistant concrete. *Lumnite Div., Universal Atlas Cement Co.*

582. Refractories

Complete details on refractory cements for every nonferrous melting operation are available in catalog 863. *Norton Co.*

583. Rust Preventives

80-page color illustrated, conveniently indexed book discusses the various No-Ox-Id rust preventives for every industrial purpose. In addition, this booklet contains general information of value to anyone concerned with the prevention of corrosion. *Dearborn Chemical Co.*

584. Shape Cutter

A new 10-page bulletin describing low-priced portable shape-cutting machine Airco No. 3 Monograph. Illustrated booklet covers in detail various features of this unique oxyacetylene shape-cutting machine. *Air Reduction Sales Co.*

585. Slitting Lines

74-page book describes the multiple rotary slitting lines. Prepared in two parts: part 1 gives basic information on design selection and operation of slitter and slitting lines. Part 2 contains specifications, capacity tables and other data on Yoder scrap choppers, coilers and recoilers. *Yoder Co.*

586. Steel, Cold Finished

16-page bulletin entitled "You Can Make Them Better with Cold Finished Jalcase" gives technical information, charts and graphs about Jalcase 10 and the other nine grades of Jalcase. *Jones & Laughlin Steel Corp.*

587. Steel Mill Equipment

Attractive bulletin illustrates complete line of hydraulic presses, steel mill equipment, iron and steel rolls, grinding machines, steel castings and jaw crushers. *Birdsboro Steel Foundry & Machine Co.*

588. Steel Selector

Handy, clearly printed, easy-to-use steel selector illustrated on page 35 will be furnished on request. *Crucible Steel Co. of America.*

589. Steel, Stainless

New illustrated booklet, "Stainless Steel for Heat Resistance", presents a concise discussion of the properties of stainless steel and outlines the proper grades to use for parts subjected to heat. *Armco Steel Corp.*

590. Steels, Alloy

New book is now available on the selection of the proper alloy steel grades for each manufacturer's needs. Write for free copy of "Wheelock, Lovejoy Data Book". *Wheelock, Lovejoy & Co.*

591. Steels, Heat Treated

New bulletin gives engineering data on Rycrome and Nikrome "M", two high-performance alloy steels supplied in the heat treated condition, ready for use in heavy-duty applications. *Joseph T. Ryerson & Son, Inc.*

592. Tool Steels

New 4-page brochure describes and lists prices of three tool steels — Watercrat, Oilcrat and Aircrat. *Marshall Steel Co.*

593. Tubing, Seamless

New 52-page "Handbook of Seamless Steel Tubing" tells how to get uniform results at lower costs in your machining and heat treating operations. *Timken Roller Bearing Co.*

594. Welding

Information available on fast, clean, process for welding sheet steel with the Heliarc torch. *Linde Air Products Co.*

595. Welding, Spray

New hard-facing method using the Colmonoy Spraywelder described in bulletin along with various accessories for different operations. *Wall Colmonoy Corp.*

596. Wire Cloth

32-page booklet is an introduction to the variety of equipment necessary for the production and processing of all grades of industrial wire cloth and screens. *Ludlow-Saylor Wire Co.*

597. Zinc, Coatings

16-page illustrated booklet discusses the origin of galvanizing, the various zinc coating methods employed today and the advantages of zinc as a protective coating for iron and steel products. *St. Joseph Lead Co.*

[• If mailed from countries outside the United States, proper amount of postage stamps must be affixed for returning card]

METAL PROGRESS

7301 Euclid Avenue, Cleveland 3, Ohio

July, 1950

512	530	548	566	584
513	531	549	567	585
514	532	550	568	586
515	533	551	569	587
516	534	552	570	588
517	535	553	571	589
518	536	554	572	590
519	537	555	573	591
520	538	556	574	592
521	539	557	575	593
522	540	558	576	594
523	541	559	577	595
524	542	560	578	596
525	543	561	579	597
526	544	562	580	
527	545	563	581	
528	546	564	582	
529	547	565	583	

Please have literature circled at the left sent to me.

Name _____ **Title** _____

Company _____

Products Manufactured _____

Address _____

City and State _____

Postcard must be mailed prior to October 1, 1950— Students should write direct to manufacturers.

. . . when you use "NATIONAL" Graphite Stool Inserts

● *It is impossible for molten metal to stick to graphite under any conditions.* This means that an ingot cannot possibly stick to a graphite stool insert. If you are bothered with stickers, equip your stools with "National" graphite stool inserts.

Think of the savings!

No lost time in freeing stuck ingots. Keeps maintenance costs down. For complete information on "National" graphite stool inserts, write to National Carbon Division, Union Carbide and Carbon Corporation, Dept. MP.

The terms "National" and "Eveready" are registered trade-marks of

NATIONAL CARBON DIVISION
UNION CARBIDE AND CARBON CORPORATION
30 East 42nd Street, New York 17, N. Y.

District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

Foreign Department: New York, U. S. A.

MORE THAN DOUBLE THE USABLE LIGHT!

The biggest news since the invention of flashlights—the brand new leakproof "Eveready" No. 1050 flashlight battery—gives more than double the usable brilliant white light for critical uses than any other flashlight battery we have ever made. NO METAL CAN TO LEAK OR CORRODE.

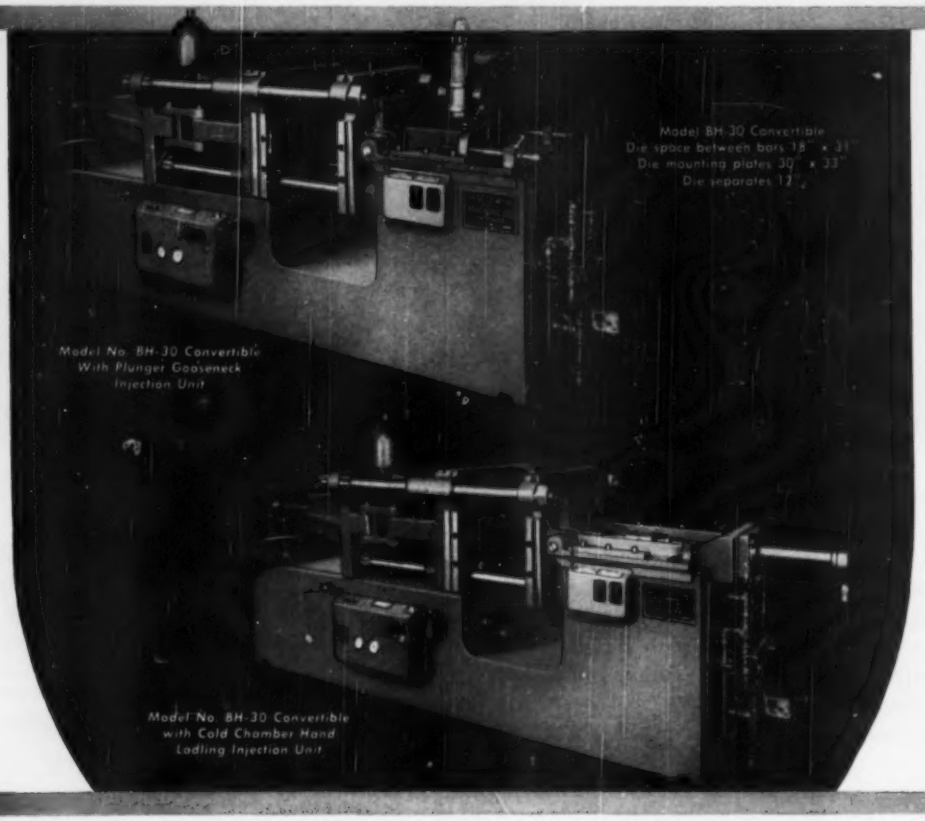
CONVERSION FROM ZINC TO ALUMINUM DIE CASTING

in less than an hour on

KUX CONVERTIBLE MACHINES

In less than an hour's time, Kux hydraulic machines can be adjusted for die casting zinc alloys using a plunger gooseneck metal injection unit or for die casting aluminum brass or magnesium alloys using a cold chamber hand ladling injection unit.

This change over is a simple easy operation on any of the Kux machines from Model BH-18 to Model BH-30 which are available as convertibles. The removal of a few mounting screws and pins and the attachment of either injection unit, both completely self-contained, rapidly readies a machine for production. Only on Kux Die Casting equipment can you find so many superior design features that offer such a multiplicity of usage for each machine. Write now for illustrated catalog.



KUX MACHINE COMPANY

3940 W. HARRISON STREET • CHICAGO 24, ILLINOIS

"no more GAMBLING on tool steel selection"

[½ actual size; Selector is in 3 colors]

Since the first announcement, hundreds of tool steel users have received their CRUCIBLE TOOL STEEL SELECTORS. The comments received indicate that this handy method of *picking the right tool steel right from the start* is going over big.

"Handiest selector I've ever seen"

"No more gambling on tool steel selection"

"You're right, the application should dictate the choice of the tool steel" . . . and many, many more favorable comments.

You'll want your CRUCIBLE TOOL STEEL SELECTOR. It uses the only logical method of tool steel selection—begin with the application to pick the right steel! And the answer you get with one turn of the Selector dial will prove satisfactory in every case, for the CRUCIBLE TOOL STEEL SELECTOR covers 22 tool steels which fit 98% of all Tool Steel applications. ALL the tool steels on the Selector are in Warehouse Stock . . . that means when you get the answer, you can get the steel . . . fast!

Write for your Selector today! We want you to have it, because we know you've never seen anything that approaches your tool steel problems so simply and logically. Just fill out the coupon and mail. Act now! CRUCIBLE STEEL COMPANY OF AMERICA, Chrysler Building, New York 17, N. Y.

Here's how it works:

To use the Selector, all you need know is the characteristics that come with the job: type and condition of material to be worked, the number of pieces to be produced, the method of working, and the condition of the equipment to be used.

FOUR STEPS—and you've got the right answer!

1. Move arrow to major class covering application
2. Select sub-group which best fits application
3. Note major tool characteristics (under arrow) and other characteristics in cut-outs for each grade in sub-group
4. Select tool steel indicated

That's all there is to it!

Here's an example:

Application—Deep drawing die for steel

Major Class—Metal Forming—Cold

Sub-Group—Special Purpose

Tool Characteristics—Wear Resistance

Tool Steel—Airdi 150

One turn of the dial does it!

And you're sure you're right!!

Crucible Steel Company of America
Dept. MP, Chrysler Building
New York 17, N. Y.

Gentlemen:

Sure! I want my CRUCIBLE TOOL STEEL SELECTOR!

Name _____ Title _____

Company _____

Street _____

City _____ State _____

CRUCIBLE first name in special purpose steels

TOOL STEELS

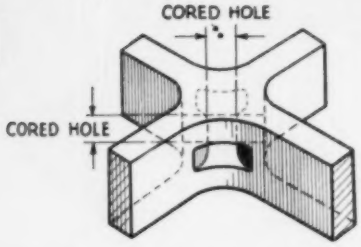
fifty years of Fine steelmaking

Branch Offices and Warehouses: ATLANTA • BALTIMORE • BOSTON • BUFFALO • CHARLOTTE • CHICAGO • CINCINNATI • CLEVELAND • DENVER • DETROIT HOUSTON, TEXAS • INDIANAPOLIS • LOS ANGELES • MILWAUKEE • NEWARK • NEW HAVEN • NEW YORK • PHILADELPHIA • PITTSBURGH • PROVIDENCE ROCKFORD • SAN FRANCISCO • SEATTLE • SPRINGFIELD, MASS. • ST. LOUIS • SYRACUSE • TORONTO, ONT. • WASHINGTON, D. C.

MISCO HEAT RESISTING ALLOY GRID TRAYS

MORE LOAD · LESS DISTORTION · LONGER LIFE

Do You Use PUSHER TRAYS—Have YOU Tried *This* Design?



THE MISCO PRINCIPLE OF GRID BAR DESIGN

Grid intersections are cored horizontally and diagonally through the neutral axis. Metal thus removed from regions of low stress is added to areas of high stress, where it increases load capacity, reduces distortion, and gives much longer life. U.S. PAT. 2242554.

The one-piece grid type is simple, light and efficient. The Misco patented grid-bar feature provides the strongest, most rugged tray construction yet devised. Users are enthusiastic reporting tray life up to 4½ years. *You get maximum endurance when Misco builds your equipment.*

ALLOY CASTING DIVISION
Michigan Steel Casting Company

MISCO
Heat and Corrosion Resistant Alloys

One of the World's Pioneer Producers and Distributors of Heat and Corrosion Resisting Alloys

1998 GUOIN STREET • DETROIT 7, MICHIGAN

MAKE A TON OF SHEET STEEL GO FARTHER

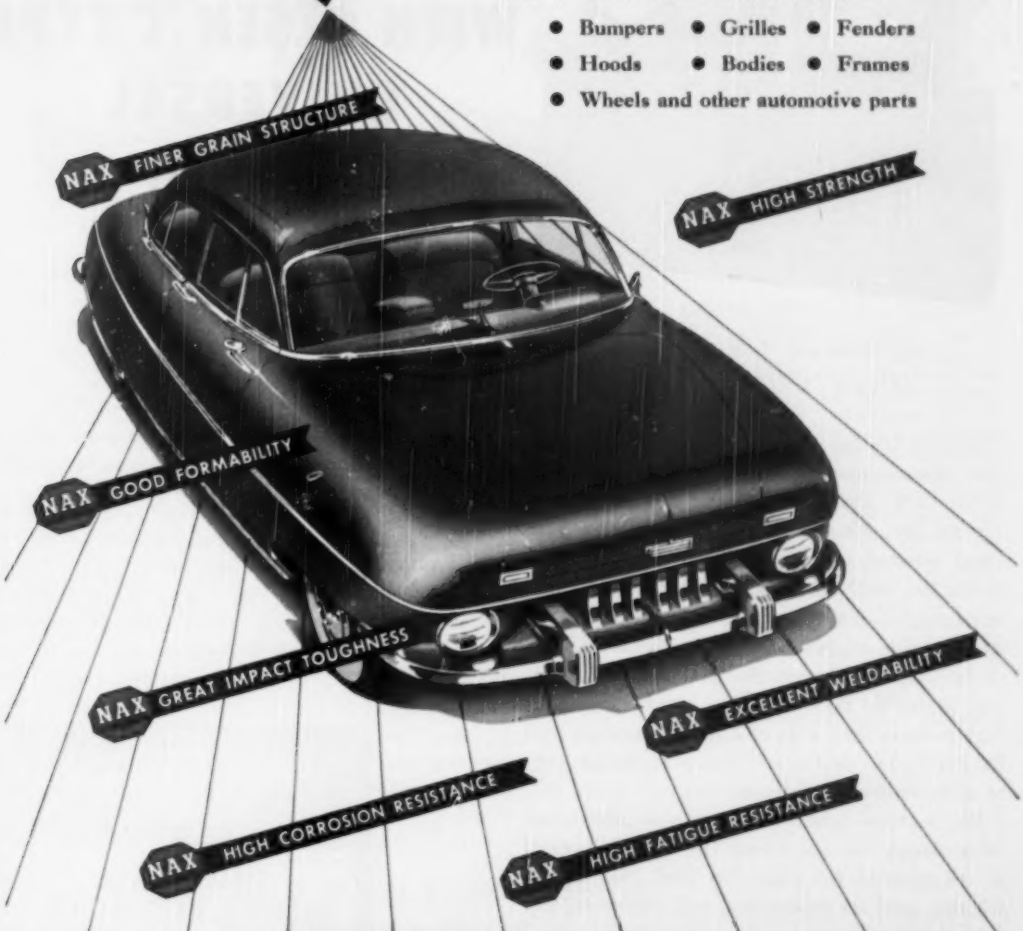
Specify—

N-A-X

HIGH-TENSILE STEEL

SEVEN STRONG REASONS explain the trend to N-A-X HIGH-TENSILE steel for:

- Bumpers
- Grilles
- Fenders
- Hoods
- Bodies
- Frames
- Wheels and other automotive parts



GREAT LAKES STEEL CORPORATION N-A-X ALLOY DIVISION • ECORSE, DETROIT 29, MICH. • UNIT OF NATIONAL STEEL CORPORATION

NEW LOW TESTING RANGES!

WITH OLSEN "L" TYPE UNIVERSAL TESTING MACHINE

"Atcotran" Electronic Null System now available on New Olsen "L" Machines — or can be added to present units.

The Olsen low cost "L" Universal Testing Machine now becomes more versatile than ever. Available in standard capacities of 60,000 lbs., 90,000 lbs., 120,000 lbs., 300,000 lbs., and 600,000 lbs. with usual selected secondary ranges of 10,000 lbs., 20,000 lbs., 30,000 lbs., 60,000 lbs. and 100,000 lbs. respectively—new "extra low" capacity ranges are now possible on these machines with the addition of the "Atcotran"* unit. For example, a 60,000 lb. and 10,000 lb. machine can be readily provided with an extra low range of 1,000 lbs., reading by 2 lb. dial marks. And in addition, load changes may be made without stopping the test.

For accurate tension, compression, and transverse testing the new Olsen "L" Type Universal is unsurpassed for versatility and low cost — whether used for production, and quality control testing or instruction.

*The "Atcotran" was developed in conjunction with the Automatic Temperature Control Company, Philadelphia. An electronic null system consisting of only three moving parts, it receives signals from the developed hydraulic pressure in the precision cylinder of the "L" machine and electronically translates them into the rotary motion of the pointer. This system is extremely accurate and the low ranges which it makes possible are guaranteed accurate within ASTM requirements.

TINIUS OLSEN

Testing & Balancing Machines

TINIUS OLSEN
TESTING MACHINE CO.
2030 Easton Rd., Willow Grove, Pa.

JALCASE 10

- - - - - - the top grade of J&L
cold finished JALCASE - - - - WITH
HIGH MECHANICAL PROPERTIES

J&L STEEL

. . . and all the high machinability properties of other Jalcase grades

When the shop bull-sessions get started on "better than average" steels, and the boys get down to fine points, you can be sure that Jalcase 10 (AISI No. C-1144) will come up for discussion. That's because Jalcase 10 is the grade of cold-finished Jalcase steel made for those tough and "in between" applications.

Many times finished part specifications call for a high degree of hardness—but not as high a degree as that obtained through heat treating of the finished part. In these applications, manufacturers and machinists have found it profitable to use Jalcase 10 and dispense with heat-treating processes altogether.

Machinists who know their stuff also know that Jalcase 10—the highest carbon grade of Jalcase—has high mechanical properties. They know that Jalcase is the original cold-finished, open-hearth, free-machining steel. They know that Jalcase 10 has over 25 years of research and experience behind every ton produced.

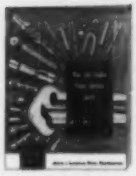
Interested in some technical data? Here are the chemical properties and mechanical properties of Jalcase 10:

CHEMICAL

Carbon Range	.40-.48
Manganese Range	1.35-1.65
Maximum Phosphorus	.045
Sulphur Range	.24

TYPICAL PHYSICAL PROPERTIES

Tensile Strength	134,050 lb./sq. in.
Yield Strength	107,840 lb./sq. in.
Elongation in 2 inches	13.5%
Reduction of Area	35.7%
Brinell Hardness	269



If you haven't tried Jalcase 10 yet (many shops have, and like it, too), why not send for our booklet entitled "You Can Make Them Better with Cold-Finished Jalcase." This 16-page illustrated booklet gives you technical information, charts and graphs about Jalcase 10 (and the other nine grades of Jalcase, too) that will help you make better parts.

Write Today!

Jones & Laughlin Steel Corporation
405 Jones & Laughlin Building
Pittsburgh 30, Pennsylvania

☐ Please send me a copy of "You Can Make Them Better with Cold Finished Jalcase."

☐ I am interested in making a trial run on J&L Jalcase 10. Please have a representative call.

Name_____

Title_____

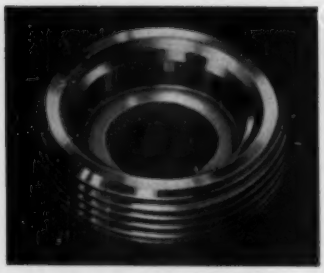
Company_____

Address_____

JONES & LAUGHLIN STEEL CORPORATION

From its own raw materials, J&L *manufactures a full line of carbon steel products, as well as certain products in* OTISCOLOY *and* JALLOY *(hi-tensile steels).*

PRINCIPAL PRODUCTS: HOT ROLLED AND COLD FINISHED BARS AND SHAPES • STRUCTURAL SHAPES • HOT AND COLD ROLLED STRIP AND SHEETS • TUBULAR, WIRE AND TIN MILL PRODUCTS • "PRECISIONBILT" WIRE ROPE • COAL CHEMICALS



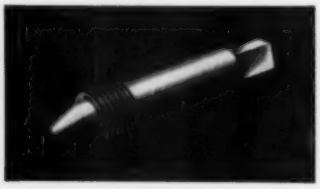
here is PROOF that you can reduce unit costs by using *Carpenter* Free-Machining Stainless

1 **UNIT COST GOES DOWN!**

At first this bearing race job was classed as "impossible"—slow production, excessive rejects and a high unit cost. But now that Carpenter Stainless No. 8 (Type 303) is on the job, *each unit costs only five cents, tool life has doubled and rejects have dropped by 40%.*

2 **SAVED: $456.00 EACH YEAR ON TOOL REGRINDING!**

The cost of each Stainless part is bound to come down when you make a saving like that. *Tool life jumped from a few hours to over 15 days, plus the fact that less down time on machines gave the company production time for over 23,000 extra valve needles per year.* Small wonder that the company is pleased with Carpenter Stainless No. 8 (Type 303).



3 **PRODUCTION UP 25%!**

The Plant Manager told us that he has tried many Stainless Steels, and is convinced that Carpenter Stainless No. 5 provides the best finishes and *machines 25% faster than competitive materials.*

To get results like these time after time, the Stainless that feeds into your machines has to be *uniform* from bar to bar. It has to work the same in your machines month after month. And that is just why you need Carpenter Free-Machining Stainless on your jobs.

If you want positive proof that you can reduce your unit costs with *consistently uniform* Carpenter Free-Machining Stainless bar stock—do this. Place your next production order with the nearest Carpenter warehouse listed below. Send your order to Carpenter and find out for yourself that—

YOU CAN TURN IT OUT AT LESS COST WITH *Carpenter* FREE-MACHINING STAINLESS

"Big Help to Getting More Parts From Every Pound of Stainless" . . .

That is what customers say about the Carpenter "NOTEBOOK on Machining Stainless Steels" with its 96 pages of useful information on Turning, Drilling, Tapping, Threading, etc. For your copy, just drop us a note on your company letterhead. Extra copies of the NOTEBOOK, for the men in your plant, are available at 50¢ each.

THE CARPENTER STEEL COMPANY, 133 West Bern Street, Reading, Pa.

Export Department: 233 Broadway, New York 7, N.Y. "CARSTEELCO"

Carpenter

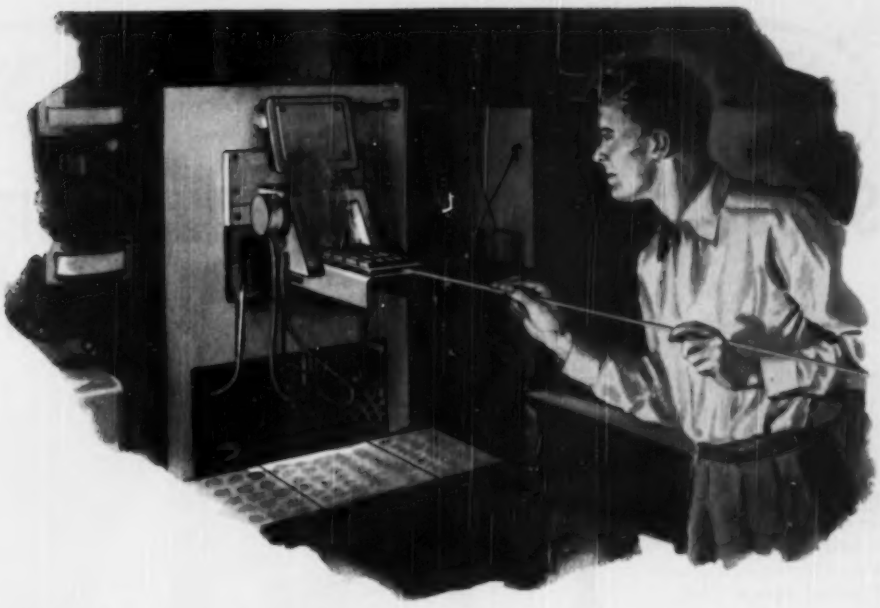
FREE-MACHINING

STAINLESS STEELS

When You Want *Rush* Delivery Call Your *Carpenter* Warehouse—

BOSTON	CINCINNATI	HARTFORD	PHILADELPHIA
BRIDGEPORT, CONN.	CLEVELAND	INDIANAPOLIS	PROVIDENCE
BUFFALO	DAYTON	LOS ANGELES	ST. LOUIS
CHICAGO	DETROIT	NEW YORK	WORCESTER, MASS.

SEE YOUR CLASSIFIED TELEPHONE DIRECTORY

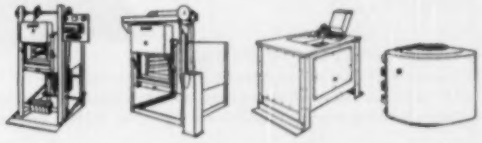


Dependable performance year after year with Hoskins Chromel -equipped Electric Furnaces

There's nothing revolutionary about Hoskins Furnaces, but you'll find them hard to beat when it comes to delivering useful electric heat. And for good reason, too. Because every Hoskins Electric Furnace is equipped with durable CHROMEL heating elements. Long-lasting elements that possess close-to-constant "hot" resistance between 700° and 2000°F., that deliver full-rated power throughout their long and useful life. Dependable heating elements designed to give you uniform distribution of heat with maximum operating efficiency. Important, too, every CHROMEL element in every Hoskins furnace is formed in such a way as to permit quick and easy replacement.

Take the Hoskins FK Brazing Furnace illustrated above, for example. Compactly designed for brazing small tools and parts, it's economical to operate... low in hydrogen and power consumption, quick on recovery. And it's equipped with heavy-duty reverse "U" type heating units made of long-lasting 1" by $\frac{3}{16}$" CHROMEL-A ribbon.

So next time you're in need of good dependable heating equipment, get the facts on Hoskins CHROMEL-equipped electric furnaces. Our Catalog-59R describes the line . . . want a copy?



TYPE FR-206, 207, 208 BOX FURNACE | TYPE FR-251 BOX FURNACE | TYPE OR-154 POT FURNACE | TYPE FR POT FURNACE

HOSKINS MANUFACTURING COMPANY

4445 LAWTON AVE. • DETROIT 8, MICHIGAN

NEW YORK • CLEVELAND • CHICAGO

West Coast Representatives in Seattle, San Francisco, Los Angeles
In Canada: Walker Metal Products, Ltd., Walkerville, Ontario

**the ... nickel-chromium resistance alloy that first made electrical heating practical*

Why HEVI DUTY selected GLOBAR Heating Elements for new furnace design

Among the many reasons why GLOBAR silicon carbide heating elements are best suited for this new design in laboratory furnaces—dependable high temperature performance stands out. Continuous operation in the 2000°F to 2600°F range places no severe demands on element life. Response to thermal control requirements is fast and accurate. Clean, silent, uniform heating for extended periods is assured.

The elements are easy and convenient to service. All terminal connections are external. Replacements can be made in minutes... while the furnace is at temperature. Working conditions are cleaner and safer too. There is no explosion or fire hazard.

GLOBAR heating elements are being used to advantage in an increasing number of industrial heating applications. They may provide the answer to your heating problems. Complete details are available through Department X-70, The Carborundum Company, GLOBAR Division, Niagara Falls, New York.

● This new HEVI DUTY ELECTRIC CO. furnace features an improved insulation design with minimum of radiation loss... incorporates the most recent developments introduced by HEVI DUTY engineers.

GLOBAR Heating Elements BY CARBORUNDUM

TRADE MARK

"Carborundum" and "Globar" are registered trademarks which indicate manufacture by The Carborundum Company

THE FASTEST MACHINING STEEL EVER PRODUCED!

LA-LED

NEW, LEAD-BEARING OPEN-HEARTH STEEL MACHINES *TWICE* AS FAST AS B-1112

LA-LED ALSO HAS THESE IMPORTANT QUALITIES

- IMPROVED FINISH
- SOUNDER CROSS SECTION
- BETTER CARBURIZATION
- BETTER BENDING, CRIMPING, RIVETING, PROPERTIES
- CLOSER MACHINED TOLERANCES

Because machinability is such an important factor in finished part cost, new LA-LED is causing a sensation among users of free-machining screw stocks! Production runs on thousands of tons of LA-LED have resulted in increased production over B-1113 of 45% to 106%!

But LA-LED has more than super-machinability. Being an open-hearth steel, it will carburize better and have a much sounder cross section than Bessemer. Furthermore, it has inherent good ductility and surface quality, which permit bending, crimping, and riveting operations impracticable with Bessemer steels. It machines to a fine satiny finish and permits closer finished part tolerances. LA-LED is available cold finished, in rounds, 5/16" thru 3"; and in hexagons, 5/16" thru 1½".

HERE'S PROOF

WASHER INSERT

LA-LED replacing B-1112; machined from ⅞" round on Gressloo Automatic

Form Tool	R.P.M.	+ 132%
Form Tool	S.F.M.	+ 130%
Form Tool	Feed	Unchanged
Drill	S.F.M.	+ 157%
Drill	Feed	Unchanged
Tapping	S.F.M.	+ 130%
Time/Part	Seconds	— 39%
Production	Per Hour	+ 63%
Steel Cost		+ 16%

GEAR BLANK

LA-LED replacing B-1113; machined from 2¾" round on Acme-Gridley

Form Tool	R.P.M.	+ 41%
Form Tool	S.F.M.	+ 42%
Form Tool	Feed	+ 31%
Drill	S.F.M.	+ 40%
Drill	Feed	+ 76%
Time/Part	Seconds	— 40%
Production	Per Hour	+ 67%
Steel Cost		+ 13%

WRITE FOR DESCRIPTIVE PAMPHLET

LaSalle Steel Co.
1424 150th Street, Hammond, Indiana

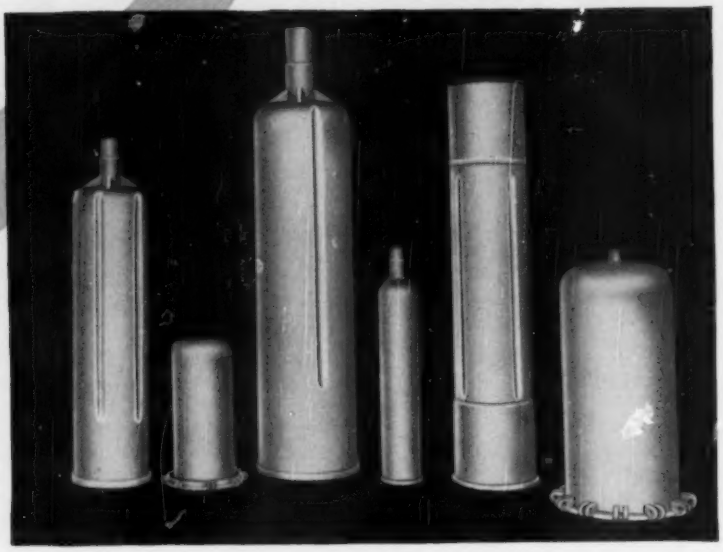
Please give me more information on how LA-LED can increase production and cut the cost of screw machine parts in my shop.

Name _____
Title _____
Company _____
Address _____
City _____ State _____

LaSalle STEEL COMPANY

Manufacturers of the Most Complete Line of Carbon and Alloy Cold-Finished and Ground and Polished Bars in America

How long should a Retort last?



3600 hrs.?... 80,000 hrs.?

Let's be honest. We could claim that our retorts last 80,000 hours. Some have. We could claim they last 10,000 or 12,000 hours. Many have.

We have also had some go out of service after 3600 hours. But even so, Thermalloy* had outlasted—for that particular service—most previously used retorts.

The point is, there are too many variables in methods of operation and maintenance for us or any other manufacturer to make general claims on retort life. These factors include: cycle of heating (batch or continuous) . . . method of heating (radiant or direct-fired) . . . frequency of charging . . . operative temperatures . . . type of suspension or support . . . efficiency of maintenance.

This we can say! In *comparable* service, Thermalloy retorts and muffles have attained an outstanding record for "more operating hours per dollar."

For recommendations on your particular installation, contact your nearest Electro-Alloys office, or write Electro-Alloys Division, 1978 Taylor Street, Elyria, Ohio.

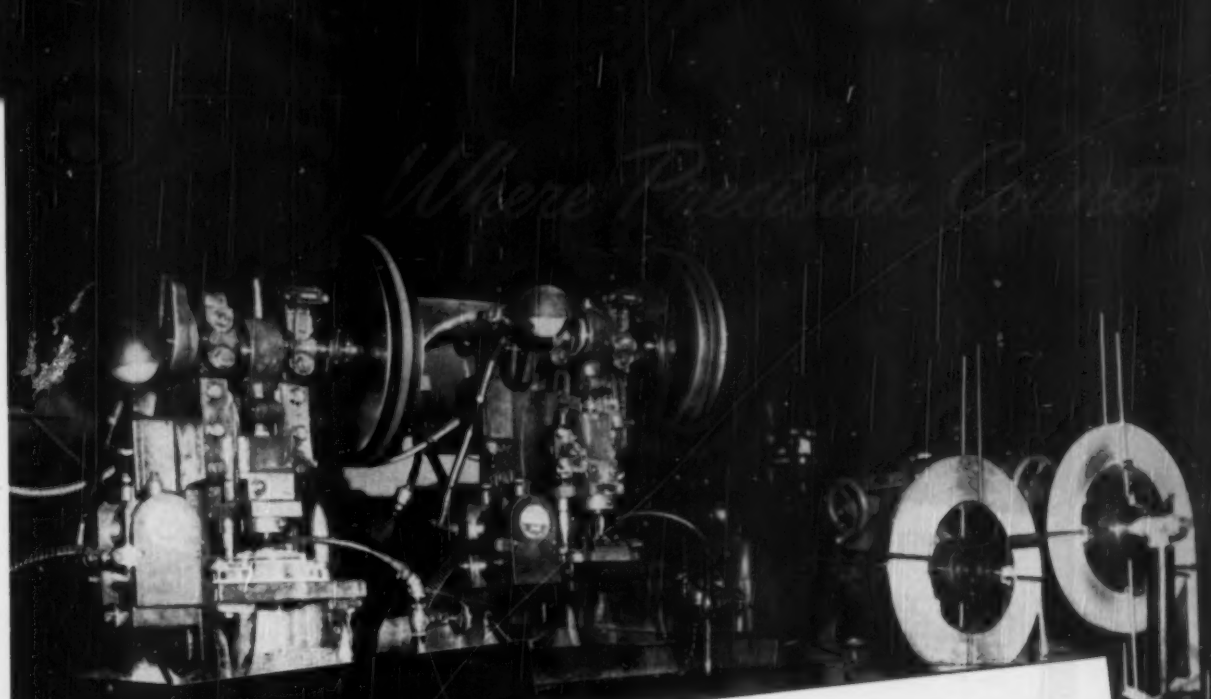
*Reg. U. S. Pat. Off.

Specify CHEMALLOY* for corrosion resistance . . . THERMALLOY* for heat and abrasion resistance

Write for Technical Booklet—Cast 16% Cr.—35% Ni Alloys

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO



Sharon Stainless
Does a Better Job

Where extreme accuracy is required manufacturers demand uniformity of material.

Sharon's ability to produce Stainless Steels conforming exactly to customer's requirements —year in and year out—is the one big reason why Sharon tops the list as a leading producer of Stainless Steel for precision parts.

If you are thinking of Stainless — think of Sharon, pioneer and prime producer of fine steels for 50 years.

SHARON STEEL CORPORATION

Sharon, Pennsylvania

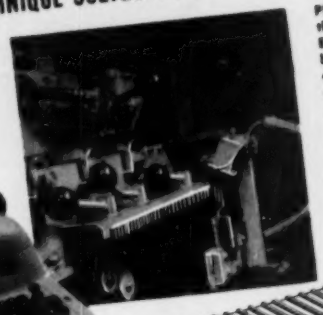
THER-MONIC

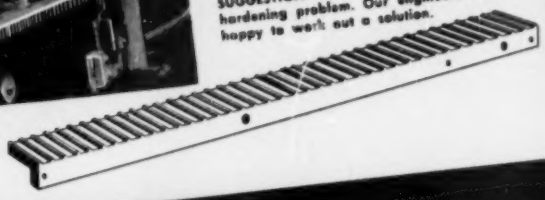
THER-MONIC INDUCTION HEATING CORP. NEW YORK

NEW DEVELOPMENTS IN ELECTRONIC HEATING!

NEW THER-MONIC TECHNIQUE SOLVES RACK GEAR HARDENING PROBLEM FOR IBM

Section of semi-automatic work table developed for I.B.M. Operator simply places rack gear in this specially designed indexing fixture . . . presses start button! Subsequent operations are automatic!





PROBLEM: Many approaches to hardening the teeth of special rack gears for IBM Electric Typewriters were unsatisfactory because they required costly straightening operations to correct distortion.

SOLUTION: Ther-monic's newly developed Induction Hardening Technique and equipment.

RESULTS: No rejects! No distortion! . . . And, straightening operations were practically eliminated.

SUGGESTION: You, too, may have a difficult hardening problem. Our engineers will be happy to work out a solution.

NEW THER-MONIC CORE BAKING TUNNEL BAKES 133 LBS. OF SAND CORES PER MINUTE, FROM START TO FINISH!

The Ther-monic core baking process makes it possible to reduce handling and breakage. Cores up to 20" x 60" in any length are baked evenly throughout, with no green centers. The Ther-monic process achieves a finer core finish, eliminates over-baked and burned surfaces. No cooling period is required . . . cores, after leaving tunnel, are immediately ready for inspection and use. Ther-monic baked cores are highly resistant to cracking during the pouring operation—reduce finning to a negligible factor. Write for complete details!

MODEL M7200

Capacity: Four Tons of Sand Cores Per Hour

Overall dimensions of Conveyor and Electrode Housing: 8' x 8' x 32'

INDUCTION HEATING CORPORATION

181 WYTHE AVE., BROOKLYN 11, N.Y.

Inclusion-free high-carbon ferro chromium

assured by new process

MOST ball and roller bearings must take terrific punishment in service, and their dependability is based directly upon the quality of steel from which they are made.

To meet the requirements of the bearing manufacturer and his customers, the steelmaker can rely upon our newly improved ferro chromium to help him produce consistently high grade bearing steels.

The high-carbon ferro chromium we have recently developed is exceptionally free from non-metallic inclusions, entrapped slag and dissolved gases. It is made by a new process* which includes filtering out harmful inclusions by pouring the metal, as tapped from the furnace, through a layer of molten slag of special composition. In addition to removing the undesirable inclusions, this process also assures greater density of the metal and the absence of shrinkage cavities in individual lumps.

High-carbon ferro chromium contains 66 to 70 per cent chromium, 4 to 6 per cent carbon, and 3 per cent maximum silicon.

Our technical staff will be glad to demonstrate to you the benefits to be gained in your steelmaking by the use of this improved high-carbon ferro chromium. *Patented

MAKERS OF ALLOYS CHEMICALS AND METALS

VANADIUM CORPORATION OF AMERICA

420 LEXINGTON AVE., NEW YORK 17, N. Y.
CHICAGO • DETROIT • CLEVELAND • PITTSBURGH

For better results in treating metals: Specify these long-lived Norton Refractories

tubes

Alundum Refractory tubes are made in a variety of sizes for electric furnaces of the metal resistor type. Because of the excellent electrical qualities of Alundum the resistor can be wound directly in the tube. They are used largely in furnaces for wire drawing, particularly tungsten and molybdenum and for sintering cemented carbides. Crystolon tubes can be supplied in the same sizes for many high temperature operations where electrical insulation is not a factor. Alundum is also available as thermocouple tubing and as pyrometer tubes, both ideal, for protecting costly thermocouples in temperature recording devices.

cores

Alundum cores are very useful in furnace manufacture. They have all the properties of Alundum tubes with the added physical feature of being molded with grooves for retaining the resistor wire. For the operator who must prepare a special furnace on the job, cores are a great help because the resistor can be applied easily and simply in the spacing provided.

The resistor may be spiralled or straight and wound in the grooves and then embedded in Alundum cement. Thus, fully protected, the wire is less liable to corrode since these mixtures are chemically inert. Alundum cores have high heat conductivity and do not become electrical conductors even at high temperatures.

muffles

One-piece muffles of both Alundum and Crystolon can be provided, rectangular, "D" shape and "U" shape for building small furnaces heated by oil, gas or electricity. Such furnaces are used in a great variety of operations and most prefabricated furnaces on the market have furnace chambers formed by muffles of one or the other of these materials. Only Crystolon muffles are carried in stock, but Alundum muffles are gladly supplied on order. Alundum muffles are used primarily where electrical resistance is desired at temperatures above 1250° C. In electric furnaces the resistance wire encircling the muffle should be embedded in Alundum cement.

small furnace refractories

mixture designation	composition	structure	shapes available	remarks
RA 98*	alumina 89%	fine	cores, tubes, muffles and most special shapes	subject to reduction of silica above 1450° C. in reducing atmosphere.
RA 1139*	alumina 99%	fine	cores, tubes, muffles and many special shapes	used to 1650° C. but subject to distortion above 1550° C. under load.
RA 1192*	alumina 99+%	fine	tubes and certain flat and simple shapes	used to 1750° C. but subject to some distortion above 1600° C. under load.
RA 1213	alumina 99+%	medium	tubes, certain cores, muffles, and flat and simple shapes	used to 1900° C., little distortion in use to 1800° C.
RA 1191	alumina 99+%	coarse	tubes, certain muffles and flat shapes	used to 1900° C., little distortion to 1850° C.; coarse grained surface.
RC 217*	silicon carbide 65%	fine	cores, tubes, muffles and special shapes	reduction, oxidation and electrical conductivity increase with temperature; not recommended for use above 1100° C.; suitable for use with base metal resistors only.
RC 1138	silicon carbide 83%	medium fine	some cores, tubes, muffles and special shapes	reduction, oxidation and electrical conductivity increase with temperature; not recommended for use above 1450° C.; suitable for use with base metal resistors only.

*suitable electrically heated furnaces only.

refractory cements

In the construction of externally wound electric furnaces, tubes and muffles are covered with a cement to hold the resistor in place and to protect it from contamination by materials which might damage it. Norton cement mixtures are composed of Alundum grain, suitably sized, to which is added a ceramic binder. Norton refractory cements used for imbedding resistor elements are purposely designed to reduce possible reaction to the minimum.

Can't be beat for handling heat!

Norton Company • Worcester 6, Mass.

NORTON REFRACTORIES

Copyright, 1950, by American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio. *Published monthly; subscription $7.50 a year in U.S. and Canada (foreign, $10.50); single copies $1.50. Entered as second-class matter, Feb. 7, 1921, at the post office at Cleveland, under the Act of March 3, 1879.* *The American Society for Metals is not responsible for statements or opinions printed in this publication.* *Requests for change in address should include old address of the subscriber; numbers missing due to "change in address" cannot be replaced; claims for undelivered copies must be made within 60 days.*

METAL PROGRESS

Vol. 58 *July, 1950* *No. 1*

Table of Contents

Cover, representing rail sections, by Carol Marshall

Technical Articles

Problem of Decarburization in Railroad Materials, by Ray McBrian .. 51
Alcoa's New Plant at Point Comfort, Texas .. 56
Castings Improved by the Use of Graphite Molding Material, by Vladimir A. Grodsky .. 60
Conservation of Columbium, by John F. Tyrrell .. 63
Stainless Passenger Equipment Untouched by 13 Years .. 69
Heating Diesel-Powered Passenger Trains, by E. A. Russell .. 71
Health Hazards in Metal Degreasing, by Paul W. McDaniel .. 77
Stress Relief, Commentary by T. McLean Jasper and Wm. C. Stewart .. 79
The Modulus of Elasticity — A Review of Metallurgical Factors, by John E. Dorn and Thomas E. Tietz .. 81
Effect of Temperature on the Modulus of Elasticity, by Charles W. Andrews .. 85

Correspondence

Test Bar Results Compared With Tests on Components, by H. J. Maier 72
Residual Stresses in Chromium-Plated Steel, by Hugh L. Logan .. 75
Residual Stresses and Fatigue Strength, by D. Rosenthal and G. Sines 76

Departments

Data Sheet: Exposures for Cobalt-60 Radiography of Steel, by A. Morrison .. 80-B
Personals .. 90, 92, 94
Engineering Digest of New Products .. 27, 28, 30, 32
Manufacturers' Literature .. 32-A, 32-B
Advertisers' Index .. 120

Editor

Ernest E. Thum

Associate Editor

Taylor Lyman

Consulting Editors

Adolph Bregman
Harold J. Roast

Advisory Board

Albert W. Demmler
O. W. Ellis
A. E. Focke
Muir L. Frey
J. D. Hanawalt
Walter Jominy
L. A. Lindberg
Howard Scott

Published by

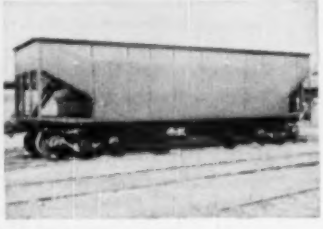
THE AMERICAN SOCIETY FOR METALS

high strength-to-weight ratio does the job

Inland HI-STEEL

MORE PAYLOAD!

Result: Operating costs of mobile equipment fabricated of Inland HI-STEEL are greatly reduced.



LIGHTER!

Result: Payloads of mobile equipment fabricated of Inland HI-STEEL can be greatly increased.

NO STRENGTH LOSS!

Result: Higher strength permits use of lighter sections. Three tons of HI-STEEL will usually produce the same number of units requiring four tons of ordinary structural-grade carbon steel.

And Inland HI-STEEL can be worked either hot or cold with little or no change in standard shop practice.

High strength, low alloy Inland HI-STEEL has nearly twice the yield strength of ordinary structural-grade carbon steel! It permits weight reductions up to 25% of total unit weight and at the same time affords greater resistance to abrasion and atmospheric corrosion.

INLAND

INLAND STEEL COMPANY, Dept. MP-70 38 S. Dearborn Street, Chicago, Illinois

OTHER PRODUCTS: BARS • STRUCTURALS • PLATES • SHEETS • STRIP • TIN PLATE • FLOOR PLATE • PILING • RAILS • TRACK ACCESSORIES.

Sales Offices: Chicago, Davenport, Detroit, Indianapolis, Kansas City, Milwaukee, New York, St. Louis, St. Paul.

The author believes that producers of railroad equipment are insufficiently aware of the problems posed by decarburized surfaces of steel parts — or, if aware, are not taking proper precautions to avoid or allow for this deficiency in as-rolled or as-forged metal.

Problem of Decarburization in Railroad Materials

THROUGHOUT the years the general development of American railroad practice, despite some ups-and-downs, has been toward more concentrated traffic and increased safety. Economical handling of freight and passengers has meant bigger cars, heavier engines and longer trains. Electrified and diesel engines mean higher speeds on the average and for short stretches. The combination of greater loads and speeds throws greater stresses and higher impacts into both rolling stock and roadbed. Yet failures cannot be tolerated, not only because of the hazard to life, but because a wreck is extremely expensive in dollars and cents.

Metallurgically speaking, the demand for higher safety of engines, cars and track even at higher speeds has been met, as a general rule, first by changing to a better material and later by "beefing it up". The rail is a well-known instance. Wrought iron straps were too soft; the harder bessemer steel rail was introduced in 1862; it weighed about 56 lb. per yard. Intervening progress has been toward harder and stronger steel up to the limit of eutectoid composition, and a bigger, higher, heavier rail. Now-a-days a 130-lb. section is common on main track, and is safe for 80,000-lb. axle loads at 80 miles per hr.; the maximum 152-lb. section is used by eastern high-traffic, high-speed lines for 100,000-lb. axle loads at 100 miles per hr.

This trend toward hard steel rails of heavy section has not been without its headaches. All know of the "internal transverse fissures" that mystified steel men and railroad men alike between 1915 and 1940, until it was tracked down to "dat ol' debbil" hydrogen and cured by cooling the rails *slowly* after the last pass in the rail mill. It is too much to say, however, that the rail and other items of track construction are perfect. The method of manufacture of all rolled steel products exposes the hot metal for long times to oxidizing atmospheres; inevitably some of the carbon is burned out of the surface layers. Those decarburized surfaces lower materially the resistance to fatigue. In a piece of rail the danger is not only that the decarburized surface has a lower endurance limit than the stronger steel from which it was derived, but the rolling or peening of the softer surface under wheel action throws high compression into the surface and resultant tensile stresses into the supporting harder steel.

A further difficulty is that there is no uniformity in the amount of decarburization, the surface carbon content, or the depth to which free ferrite extends — yet all these matters are important. Variation in rail steel, for example, is shown in Fig. 1 which compares decarburization depth

By Ray McBrian
Engineer of Standards and Research
Denver & Rio Grande Western Railroad Co.
Denver, Colo.

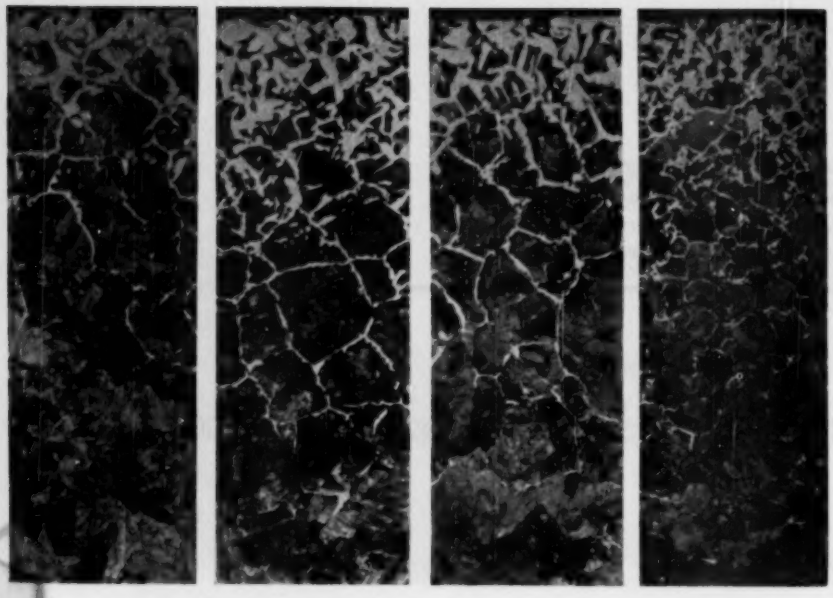


Fig. 1 — Decarburization at the Surface of Four Standard Rails From Four Rail Mills, Representative of Variables That Exist in All American Production. Magnification 100 diameters; full depth of micrographs represents 0.030 in. from the surface

and area of free ferrite (made by researches connected with the University of Illinois' Rails Investigation). It can be seen that there are variable amounts present and this greatly influences resistance of steel to fatigue failures.

It is not to be inferred from the above that rails at present are unsafe. Quite the contrary. In fact, the average American is safer when in a passenger coach than he is in his own home. Nevertheless, some unusual failures are discovered now and then during routine track inspections, that would not have occurred except for the soft skin described above.

For example, Fig. 2 shows a fatigue crack in a rail taken from the high side of a curve, in a position where normally it is considered that the rails are stressed principally in compression, yet where, in this specific case, there was very little reduction of rail dimension by wear. This rail has been removed from track, broken open, and magnafluxed to illustrate the type of fatigue cracks.

This condition was unusual in that the failure occurred on the higher elevated rail of the curve, and ordinarily this type of fatigue failure is experienced on the lower rail of curves after considerable metal has been abraded by wear. Microscopically, the decarburized condition was similar to the second from left in Fig. 1, and the carbon content at the surface was no more than 0.20%. The wheel load, as remarked, would be nearly vertical, but at times the tangential forces required to turn the cars around the curve at definite speeds would throw horizontal stresses into the rail head (directed toward the left in Fig. 2). The alternating stresses existing at the point of fracture are difficult to compute, but obviously ranged from compressive to tensile, and the range was too much for the low-carbon steel at the surface to endure.

Another example we have found emphasizes the importance of the fact that track materials in the as-rolled condition develop fatigue failures in decarburized surfaces at points of high realized stress: The joint bars are rolled sections with considerable vertical and lateral stiffness placed on both sides of the rail joint, and fastened with two bolts in each rail. Even though the bolts wedge the joint bars tightly against the underside of the head and the top side of the rail's base, there is a small amount of bending and longitudinal slip under passing wheel loads, heavily cold working and distorting the surfaces in contact (Fig. 3). Such plastically deformed surface metal (badly decarburized during manufacture) can

Fig. 2 — Longitudinal Fatigue Crack in Fillet Between Head and Web of Rail. The rail was in the outer or high side of a curve; the wheel tread and flange rolled on the upper right radius but there was very little wear, either vertically or sidewise

readily develop surface cracks, which originate fatigue fractures, as shown in Fig. 4. The location of these fractures are midlength of the joint bar — that is, very close to the location of the abutting rail ends, where all bending loads are carried by the joint bars, and alternating stresses are at a maximum.

Motive Power

With the passage of years the steam locomotive became more powerful and heavier, and its various parts more bulky (in conformity with the general principle mentioned above). Despite this apparent gain in strength, we were much disturbed over the proportionate amount of shop time required for repairs and replacements, so about 15 years ago the Denver & Rio Grande Western Railroad instituted the rule that some 30 vital locomotive parts must be magnafluxed at every general overhaul on each engine. So many siderods were found cracked that a redesign was necessary to avoid stress concentrations.

Steam pressures and temperatures were also going up and with them fatigue failure in firebox sheets and in steel staybolts — all slightly decarburized. Cracks in the crown sheets would start from rivet holes, where stresses concentrate. Not being able to get boiler plate without decarburization (nor to keep it from being decarburized when in use in contact with hot combustion gases) we changed our specification to add 0.50% molybdenum to steel of firebox quality. This enhances the strength of the ferrite very materially, and has cut our boiler troubles correspondingly.

With the advent of the diesel-electric locomotive into the American railroad field, it was thought that — due to the metallurgical experience gained by the use of the internal combustion engine in other fields — there would be no trouble from such origins as fatigue cracks originating in decarburized surfaces. However, this has not been true. Failures are occurring from this very cause, the major difference arising from the smaller physical dimensions of the diesel parts.

An unusual failure related to decarburized surface has occurred in diesel locomotive wheels. Fatigue cracks originated in decarburized surfaces in the letter and numeral stampings on the back rim of the wheel (Fig. 5). These marks had been impressed while the metal was still hot. A microsection cut normal to the surface and intersecting one of the punch marks showed decarburized surface of equal depth at all points.

In all of the years of operating steam locomotives no such types of failures were found or reported, so far as I have been able to discover.

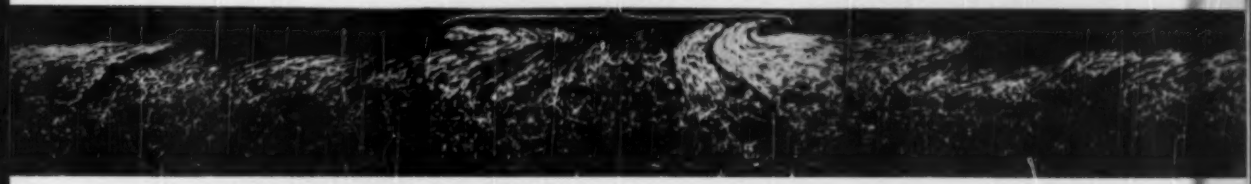
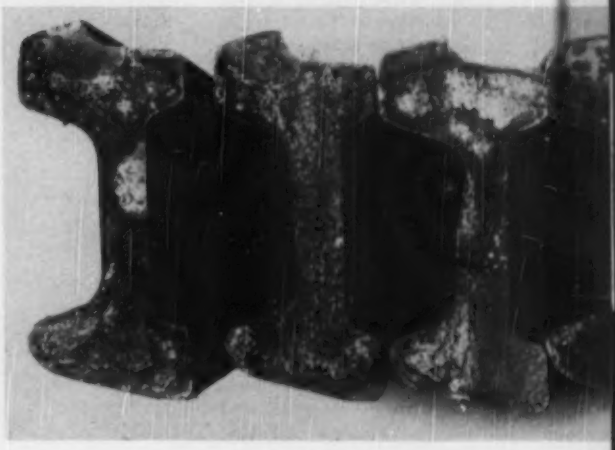


Fig. 3 (Above) — Plastically Deformed Metal Along the Decarburized Surface of Joint Bars. Note cracks where ductility is exhausted. Fatigue failures originate at or near bar's midlength, immediately under abutting rail ends (marked by bracket on photograph). Magnification 50 diameters

Fig. 4 (Below) — Typical Fatigue Cracks in Joint Bars



With the advent of the diesel-electric locomotive, its wheels of smaller diameter, higher unit pressures and higher speeds have evidently contributed to the development of this type of failure. Since all fatigue cracks must originate from tensile stresses, it is obvious that cyclic tensile stresses are present of sufficient magnitude, localized in the surface depressions to act as the notch and

to develop and progress through these depressions in forged steel wheels.

Other failures in diesel parts due to decarburized surfaces on forgings or as-rolled shapes include a crack in a valve rocker arm (Fig. 6; a forging whose surface was subsequently found to be almost totally decarburized) and a heavy coiled spring — a type of failure that is so well known it is hardly worth photographing. In the latter instance the decarburized surface was so thin (about 0.0025 in.) and so sharply differentiated from the high carbon core that it is likely the spring was coiled from ground rod and the surface damage was done during heat treatment. Since tests on spring materials and manufactured springs, made at least 20 years ago, amply demonstrate the damage done by inferior surface, and since the heat treating techniques and atmospheres required to prevent decarburization are well known and easily applicable to parts of this size, it is not too much for railroad men to expect that their suppliers use ordinary care in the production of such important parts. A little extra expense by the fabricator will save larger repair bills later on.

Fig. 5 — Magnaflux Indications (Marked by Inked Arrows) Locate Fatigue Cracks in Bottoms of Punch Marks in Wheel Rim

Fig. 6 — Rocker Arm; Fatigue Crack in Totally Decarburized Surface

Conclusion

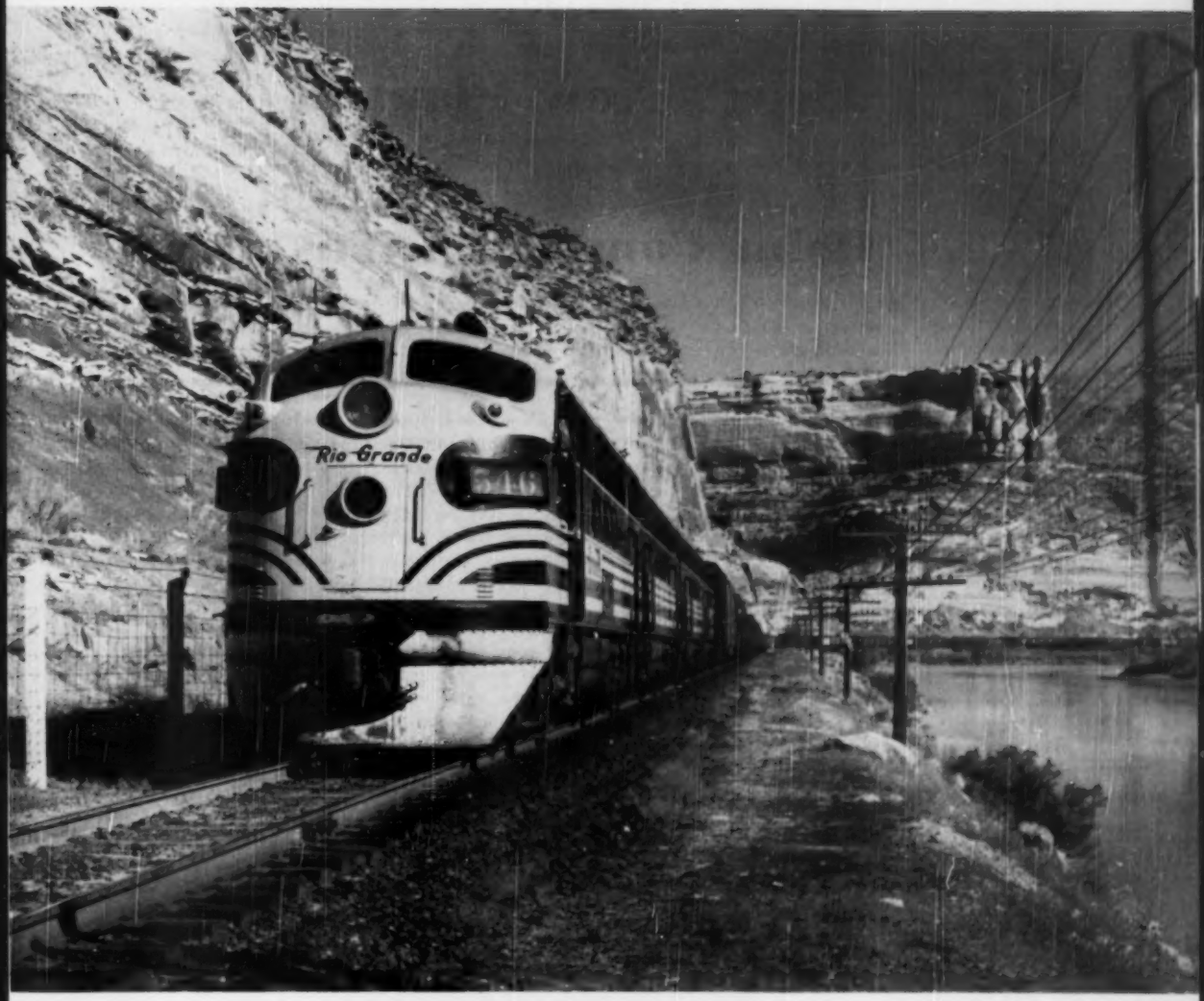
Through a study of failed railroad materials made of as-rolled or as-forged shapes, it has been found that decarburized steel surfaces are responsible for the development, under operating stresses, of fatigue failures when no other such nucleus is present.

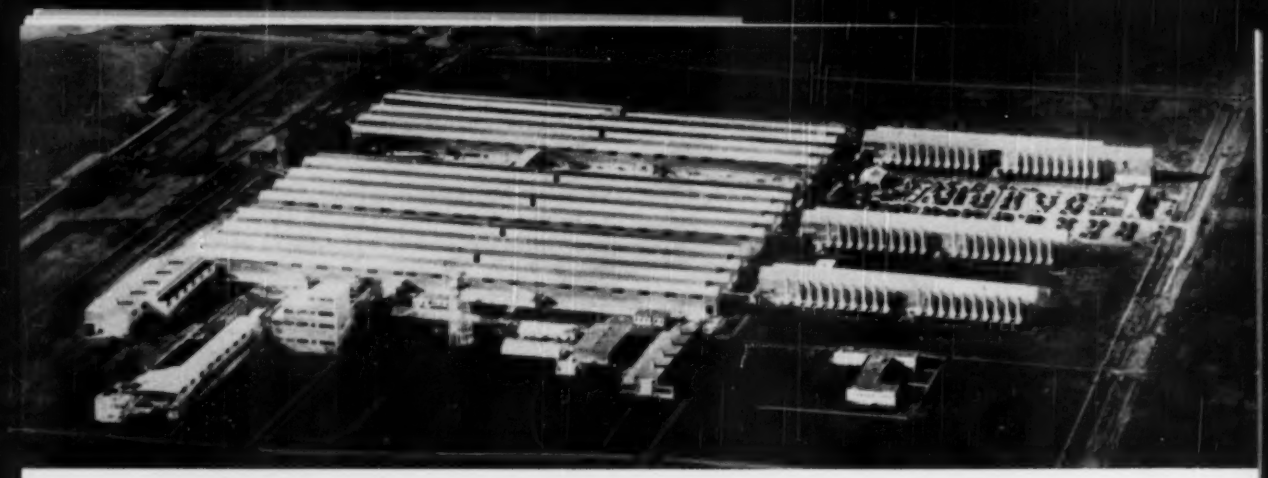
These fatigue failures originate and develop in the decarburized surface under much lower stresses and loadings than would be required to start their development on the parent material below the decarburized surface.

Very few designers of railroad materials take into consideration this important fact. As a result much earlier failures occur under railroad cyclic rolling than are expected, when compared to like material used in other industries.

Magnaflux and other methods of inspection can detect these cracks in the early stages, but the principal problem is to awaken the designers of railroad materials for present production and for future developments, to the knowledge that decarburized surfaces lower, materially, resistance to fatigue and must therefore be considered most carefully.

On the Line





Alcoa's New Plant at Point Comfort, Texas

ALUMINUM is a remarkable industry. Greatly expanded during the war, its post-war history proves the point. Its principal wartime customer building relatively few airplanes — indeed, providing the market with much secondary scrap — the aluminum industry still must bring in much new production and mill capacity to meet the demands of the 1950's. There is a rough parallel with automobile production; United States and Canada smelt six times as much aluminum ingot as the rest of the world, excluding the unknown Russians, and we use nearly all of this metal ourselves.

The wartime worry about aluminum ore supplies has been changed to a peacetime worry about power supply, for cheap power is necessary for cheap aluminum. Nearly half of the governmental-financed capacity built in the early 1940's depended on high-cost, but existing, power plants. Power is getting to be so valuable in Eastern United States for residential and manufacturing use that it is becoming increasingly difficult to justify diverting any of it to smelting; more money can be made by selling electricity to a cotton mill, for example, than by converting it to aluminum. *Cheap* power, speaking generally, no longer exists in highly industrialized or densely populated regions of America; it is to be had only on the fringes of those regions or remote from them. With this basic thought in mind it is not so surprising that more than half of the aluminum ingot made in North America is made in the South, the far West, or the extreme North, and that the most recent addition to capacity is on the Gulf Coast in Texas. Aluminum ingot is made at a distance and shipped to populous places for fabrication. In steel you can't do that; it is too heavy and the freight rates are too high. Aluminum's light weight helps much in this respect.

According to Francis C. Frary's article in *Metal Progress* for August 1949, Aluminum Co. of America then had five plants, all operating on hydro-electric power:

Niagara Falls, N. Y.	20,000 tons per year capacity
Badin, N. C.	34,000
Massena, N. Y.	57,500
Vancouver, Wash.	76,000
Alcoa, Tenn.	145,000

Faced with the necessity for closing the pioneer plant at Niagara Falls (where power became

too valuable), and with an insistent demand for metal impossible to supply with existing capacity, the company has constructed a 57,000-ton plant at Point Comfort, on the Gulf Coast in Texas, 120 miles southwest of Galveston. Here is no hydro-electric power, but a great supply of natural gas. Gas engines, direct connected to electric generators, 120 of them in three identical power plants (Fig. 1) create the energy for the three "pot lines".

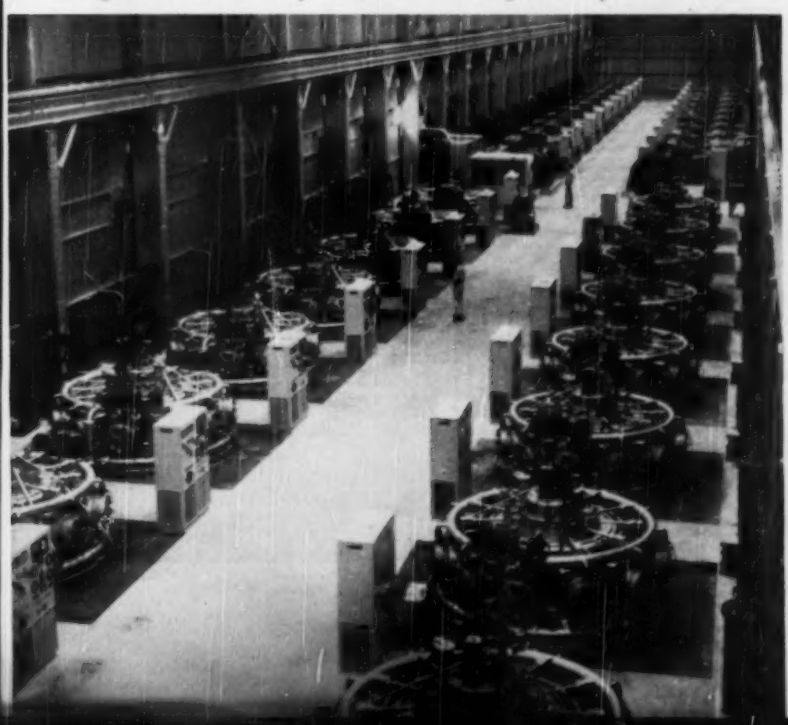
These engines, designed and built by Nordberg Mfg. Co. of Milwaukee, are unique in many respects. As seen in the photograph these have some external similarity to the radial aircraft engine. The main shaft is vertical and carries the generator's rotor below the operating floor. The eleven gas cylinders, 14-in. bore and 16-in. stroke, are in a horizontal plane, fire in rotation, but unlike the aircraft engine, drive a master gear rather than a crankshaft from which rotation is imparted to the main shaft through a proper gear train. The 11 connecting rods are attached to the master gear by knuckle pins mounted in bronze bushed bearings.

The engines are two-cycle; intake and exhaust are timed by the pistons uncovering ports in the cylinder walls, and no valves are required. Circular manifolds for scavenging and exhaust are located in the lower level of the engine room. Each engine has its own exhaust stack, 7½ ft. in diameter, 50 ft. high, fabricated on the site from ⅛-in. aluminum sheet (riveted construction). These stacks also handle cooling air from the generators and from the heat exchanger (engine radiator).

Each engine operates at 360 r.p.m., produces 1600 hp. at a thermal efficiency of 30%. Each generator (Elliott, General Electric or Westinghouse) produces 1000 kw. of direct current power at 667 volts, which is fed into an aluminum bus bar line directly leading to the pot rooms. Each generator also produces enough alternating current power to run its necessary auxiliaries, thus eliminating the possibility of a total interruption of station activities. (The generator acts as a starter motor, also.)

The engine cylinders are water cooled; this water as well as the lubricating oil is recirculated to an air-cooled heat exchanger, one for each engine. Except for cast iron manifolds, these exchangers are made of Alclad 3S alloy; tubes and fins are joined mechanically. Good thermal flow across the mechanical joint is secured by the device of expanding the tube into flanged holes in the fins.

Fig. 1 — One of the Three Power Houses. 1600-hp. radial gas engines drive vertical shafts direct connected to generators placed below



Reduction Pots

Aluminum production units known as reduction pots occupy the three major structures shown in the air view at the head of this article. Each structure, incidentally, consists of four long, narrow buildings containing 30 rectangular pots placed end to end. Thus there are three groups of 120 pots, each group connected electrically in series to the generating supply of 667 volts, the voltage drop at each cell averaging about 5.5 volts. The most prominent feature of Fig. 2, the interior of one of these pot rooms, is the laminated connectors of wide aluminum bars carrying current from the base of one pot to the electrode hangers above the succeeding one.

As far as the process is concerned, it is well known that chemically refined alumina (Al_2O_3) is dissolved in molten cryolite (Na_3AlF_6) held in a carbon lined cell or pot at about 1800° F. Electric current, led in from car-

bon electrodes suspended from above, passes through this conductive molten mixture, dissociating the alumina. The alumina collects on the pot lining, eventually forming a pool of metal on the bottom (the electrolyte having a density of 2.10, slightly lighter than molten aluminum's 2.28). The freed oxygen migrates to the carbon electrode, and reacts to CO_2 gas; electrode consumption is therefore high, being 65 to 70 lb. of carbon for every 100 lb. of aluminum.

This is the original process discovered 60 years ago by Charles M. Hall and Paul Héroult, independently and almost simultaneously. Developments since then have been in details of the process — use of artificial cryolite, construction of a rugged pot and its appurtenances such as current carrying devices and connections, discovery of optimum size and shape of individual electrodes, development of the Söderberg self-baking electrode and its support, labor-saving equipment (pavement busters on self-propelled carriers for breaking the frozen cryolite crust, and syphons for getting out the molten aluminum). The results of these many years of experience have been incorporated in this most modern Point Comfort plant.

Theoretically, close to 3 kw-hr. of electrical energy are required to dissociate enough alumina to produce 1 lb. of aluminum. Actually about 9 kw-hr. are fed into the cell per lb. of aluminum. The difference reappears as heat. Also some more heat is produced by combustion of the electrodes (reaction with liberated oxygen, plus a certain amount of combustion with surrounding air, especially when individual electrodes are used). A substantial part of the art of successful pot design and operation is concerned with the radiation and disposal of this unwanted incidental heat. It gets out through the pot structure and at the top of the bath. The pot itself is of steel plate, protected with insulating firebrick inside which is a lining of carbon-pitch mixture, baked-in as a preliminary to operations. An open-topped rectangular cavity is so formed for the molten bath. Of course the pot itself could be insulated more adequately; there is a limit to this, however, for more insulation means higher bath and electrode temperatures and larger losses of carbon through combustion of air. On the other hand, insulation must be enough to retain heat to keep the bath in a well-liquefied state — there is an obvious low limit on operating temperature.

Much of the heat escapes through the top of the bath, and a crust of frozen cryolite accumulates here, growing to as much as 3 in. thick. Subsequent charges of alumina are spread on this crust; this acts as an insulator to prevent the crust from thickening too rapidly. At the same time the alumina is preheated and any traces of moisture are driven off. At intervals of four to six hours the crust is broken up (by a pneumatic pavement buster or by hand) and the granular alumina

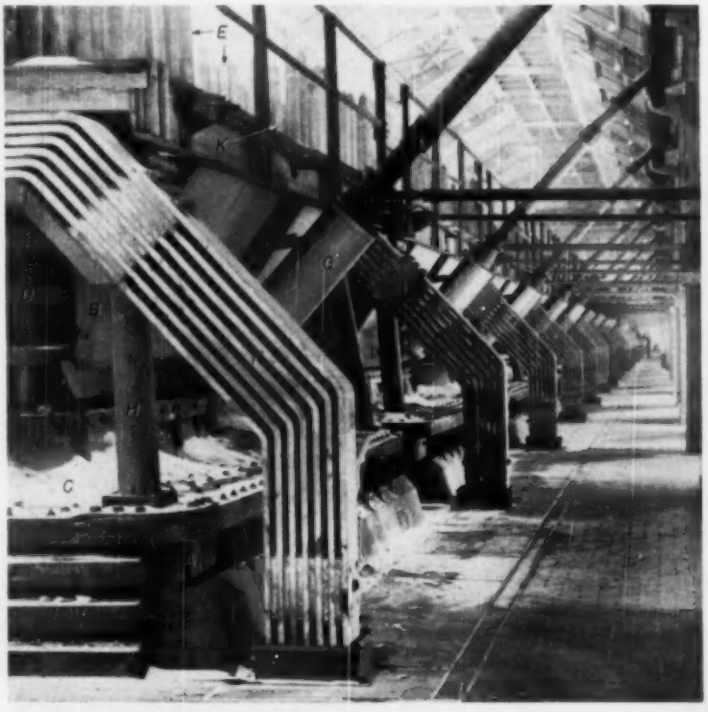


Fig. 2 — One of 12 Pot Rooms at Point Comfort Plant

A — Steel pot binding
B — Alumina bin
C — Loose alumina on frozen crust
D — Bin for carbon electrode
E — Stubs to lead current into electrode
F — Current carriers
G — Ventilator for pot fumes
H — Support for electrodes and busses
K — Cat walk

is then rabbled into the bath of molten electrolyte just below.

If the electrolyte becomes too depleted in alumina — say, below 2½% — an "anode effect" occurs; the molten bath ceases to wet the electrode, the two becoming separated by a thin film of gas which raises the resistance of the circuit as much as tenfold. If this were not corrected promptly the heat evolved by the extra resistance would raise the bath temperature disastrously. In practice, warning is given by an incandescent lamp shunted across the terminals; normally dark, it glows when the anode effect starts. The operator then breaks the crust, mixes in a new charge of alumina, flaps the molten electrolyte vigorously against the electrode, and normal operation of the cell ensues.

The unexperienced observer might imagine that, by and large, tendencies in a cell to go off normal would automatically generate their own correctives, else it would be a superhuman task to operate over a hundred pots in series. As a matter of fact, an extreme anode effect in a single cell would lower the amperage on the entire line a small amount, but if a cell gets into serious trouble it can be promptly short circuited — cut out of the operating line.

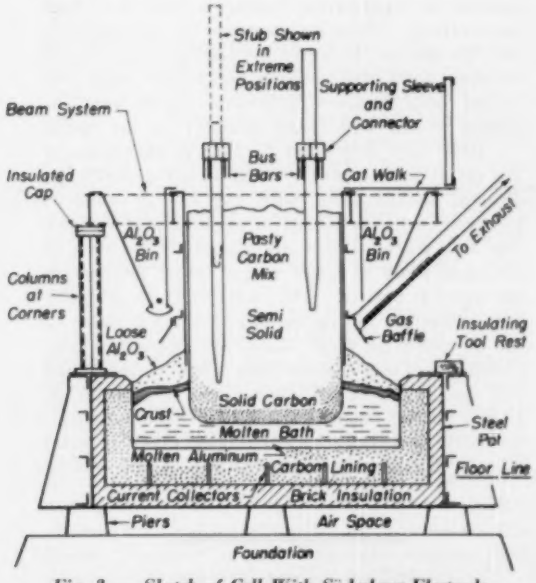


Fig. 3 — Sketch of Cell With Söderberg Electrode (Adapted From Fig. 5, "The Electrolytic Production of Aluminum" by Francis C. Frary, Journal of the Electrochemical Society, V. 94, 1948, p. 31)

Theoretically, no cryolite bath is lost in the process, but actually a little is lost through reactions with trace impurities in the alumina charged and from the carbon ash. Some is dragged out on rabbles and sucked out with the molten aluminum, but most of this is recovered and reused. New bath materials, such as cryolite, spar, and aluminum fluoride equal about 5% by weight of the aluminum produced.

Electrodes

Carbon is one of the most important subsidiary materials used in making aluminum. It must be cheap yet it must be pure — all basic impurities in the ash are reduced and contaminate the aluminum. Ground petroleum coke is pug milled with melted pitch and tar to a consistency about the same as the patching for an asphalt pavement. At the Point Comfort plant this paste is loaded into a rectangular bin, which is centered above each cell, and it forms the self-baking Söderberg electrode.

As shown in the diagram, Fig. 3, the carbon bin is a rectangular box, open top and bottom. The bottom of the mass of carbon it contains is baked hard by the heat coming up from the bath; it is baked as fast as it is consumed, and the mass is lowered periodically as the carbon wastes away and the aluminum pool is drained, so as to maintain the layer of electrolyte (and the resistance of the cell) reasonably constant. This heavy mass of carbon is supported by a double row of closely spaced steel stubs, which also lead in the electric current from the busses alongside. As the lower ends of these stubs approach the bath level, they are individually pulled by a portable jack, some soft paste dropped into the hole, the stub reset on its support at the new level and electrical connections retightened.

General Plant Construction

So much for the reduction process and equipment. As far as the plant itself is concerned, Point Comfort makes excellent use of its own metal. About 25 buildings with 18½ acres of floor space are covered with aluminum roofing and siding, fastened largely by stud welding. Fences, lamp poles, transmission towers are of aluminum wire and extrusions. Power plant auxiliaries, as already noted, including stacks, heat interchangers and air washers, are of aluminum construction. Nearly 3000 tons of aluminum bars go into electrical conductors.

A modern aluminum plant for making a modern metal!

A chilling graphite molding mixture has been developed which has the properties of a good ordinary molding sand and a much higher heat conductivity. Cost is low, especially when old broken crucibles are the source of graphite. Used as a facing for sand molds, this mixture increases mechanical properties of cast metal.

Castings Improved by the Use of Graphite Molding Material

By Vladimir A. Grodsky
Metallurgical Engineer
U. S. Naval Gun Factory
Washington, D. C.

It is well-known that the properties of cast metal are greatly affected by the speed of solidification. This speed is in direct proportion to the heat conductivity of the mold material. When the speed is slow the crystalline structure of the freezing metal is formed by equiaxial grains. With increase in speed the crystals become longer and their axes have an orientation perpendicular to the walls of the mold, forming the so-called dendritic structure. When the molten metal is heated to a temperature considerably higher than its melting point the number of nuclei from which the crystals grow is reduced and the size of the crystals becomes larger, making the structure coarser. The same occurs when a metal is held molten too long. Careless remelting acts in the same direction.

The mechanical properties of cast metal depend also on the temperature and speed of pouring and on the manner of feeding.

The majority of ferrous and nonferrous castings are poured in green or dry sand molds. Molds made of metal or some special composition are less extensively used.

When metal is poured into a sand mold, the heat is conducted from one sand grain to another with an ever-diminishing speed. The molten metal comes in direct contact with the sand of the mold only for a very short time, on account of the formation of a crust of solid metal which retards the flow of heat. Furthermore, the shrinking metal pulls away from the wall of the mold, leaving a space filled with air and other gases. This slows down the heat transfer still more. All materials used in the building of a sand mold — sand, clay, organic or inorganic binders — have low heat conductivity. Moisture increases the conductivity, but the amount of water necessary to give green molding sand the required plasticity must not exceed 10%, because otherwise steam may be formed which will create porosity in the metal.

It is very important to control shrinkage of the metal in the mold. This is done partly by directed solidification with the aid of chills — pieces of cast iron, copper or aluminum of variable size and shape. Chills are placed in the wall of the sand mold at spots where faster freezing of the metal is desired. The chills must be perfectly dry. Sweating of the chills is the main cause of the so-called blowing. Cast-iron chills can also absorb gases and release them when heated. Rust will be a source of gases too. Oxidation of aluminum and bronze chills lowers their heat conductivity. When a permanent mold made of metal is used, the mechanical properties of the casting

Table I — Thermal Conductivity of Foundry Materials

Material	Condition	K
Nonmetallics		
Graphite, Artificial	100 to 390° C.	0.338
Graphite, Artificial	100 to 914° C.	0.291
Graphite, Natural	20 to 40 mesh, 40° C.	0.0031
Graphite, Natural	100 mesh, 40° C.	0.00044
Carbon, Amorphous	100 to 360° C.	0.089
Carborundum		0.0005
Clay	360 to 600° C.	0.002
Sand, Dry		0.00093
Concrete	0° C.	0.0022
Plaster of Paris		0.0005
Water	25° C.	0.00136
Air	100° C.	0.0000719
Metals		
Copper	100° C.	0.908
Aluminum	100° C.	0.492
Magnesium	100° C.	0.376
Zinc	100° C.	0.2619
Tin	100° C.	0.145
Nickel	100° C.	0.138
Aluminum Alloys		0.309 to 0.370
Brass and Bronze		0.102 to 0.260
Steels		0.117 to 0.160
Cast Irons		0.094 to 0.135

Coefficient of heat conductivity, K, is in gram-calories transmitted in 1 sec. through a layer 1 cm. thick per 1 sq.cm. of its surface, when the difference in temperature between faces of the layer is 1° C.

are improved but the cost of the mold is often prohibitive, especially for a small number of castings. Permanent molds made of plaster of paris, cement, or other material have other drawbacks.

Of all the nonmetallic substances, graphite has the highest heat conductivity (Table I). This property has been known for a long time, and compressed graphite chills have been used in the foundry trade for years. However, these chills are quite expensive, break easily, and produce chill blows if not properly placed.

Graphite has two main forms — crystalline and amorphous. The coefficient of expansion is low and graphite withstands high temperatures without deformation; it is also nonwetting when it comes in contact with molten metal. Its slow combustion at approximately 1200° F. in the presence of oxygen creates, however, a gas film which separates the mold from the metal. The thermal conductivity and other properties of graphite depend on the nature, size, and directionality of the crystals and flakes. Artificial graphite has the highest heat conductivity, graphite powder the lowest.

The greatest use of graphite in the field of metallurgy is in the manufacture of crucibles. The better grades of crucibles sometimes contain silicon carbide, which has a lower heat conductivity than graphite but makes the crucibles much stronger.

When graphite is mixed with sand it will increase the conductivity of the latter very little. Therefore, it was logical to assume that only a molding material which has the form and shape of sand, and has graphite incorporated within its grains, can be expected to answer the purpose. Such material can be produced by burning an intimate mixture of graphite and clay, crushing it and running it through the proper sieves (V. A. Grodsky, U. S. Patent 2,201,366).

Both the crushed crucibles as well as the burned mixture of clay and graphite have to be made plastic by adding 3 to 3.5% (by volume) of bentonite, 1.5 to 2.5% (by volume) of some organic binder, and a quantity of water, so that the moisture content does not exceed 6 to 10%.

Any metal cast in a mold made from such composition immediately shows the effect of chilling.

The actual molding is very simple. The pattern is placed on a matchboard and covered by a layer of the graphite molding mixture ½ to 1 in. thick. The flask is then filled with ordinary molding sand and rammed in the usual manner. As a result the walls of the mold are

Table II — Mechanical Properties of Alloys Cast in Sand and in Graphite Mixture

	Tensile Strength	Increase With Graphite	Elongation in 2 In.	Increase With Graphite
Aluminum Alloy With 5.5% Zn, 0.6% Mg, 0.5% Cr, 0.2% Ti				
Required Minimum	32,000 psi.		3.0%	
Cast in Sand	27,370		10.5	
Cast in Graphite	33,500	22.4%	15.7	49.5%
Aluminum Alloy With 5% Si				
Required Minimum	17,000		3.0%	
Cast in Sand	19,000		8.5	
Cast in Graphite	22,000	15.7%	15.0	76.4%
Aluminum Alloy With 7% Si, 0.3% Mg				
Required Minimum	25,000		3.0%	
Cast in Sand	27,580		7.8	
Cast in Graphite	31,500	14.2%	11.5	47.4%
Aluminum Alloy With 4.5% Cu				
Required Minimum	29,000		6.0%	
Cast in Sand	35,500		9.0	
Cast in Graphite	41,250	16.2%	17.25	91.7%
Cast Phosphor Bronze With 8% Sn, 4% Zn, 0.1% Pb				
Required Minimum	30,000		12%	
Cast in Sand	44,000		34	
Cast in Graphite	47,500	7.95%	39.5	16.1%
Cast Gun Metal With 8% Sn, 4% Zn				
Required Minimum	40,000		20%	
Cast in Sand	44,000		35.5	
Cast in Graphite	50,000	13.6%	39.5	11.1%

Required minimums for aluminum alloys are from Navy Specification 46A1f; phosphor bronze, 46B5j; gun metal, 46M6h.

composed of a chilling layer about ¼ to ¾ in. thick, backed by molding sand.

Sets of aluminum test bars (Navy Specification 46A1) were cast after the melt had been degassed with small amounts of lead chloride. One bar of each set was molded in the chilling mixture. As a result each pair of bars was cast in the same flask, from the same metal, at the same temperature and speed. The only difference was that one bar was chilled and the other was not.

The increase in mechanical properties of four aluminum alloys and two copper alloys cast in a graphite chilling mixture, compared with the results obtained by casting the same alloys in ordinary molding sand, are shown in Table II. The aluminum alloys were particularly responsive, with an increase in tensile strength up to 22.4% and elongation up to 91.7%.

The fracture of chilled test bars showed always a much finer structure than the fracture of bars cast in sand. To compare the structure of larger aluminum alloy castings, two 3 x 3 x 3-in. blocks were cast in the same flask. Block A was molded in sand and block B in a graphite molding mixture (Fig. 1). Both blocks were macro-etched with a solution of 20% HCl, 5% $FeCl_3$ and a few drops of HF. (If the etch is too strong a few drops of glycerin should be added.) Micrographs were taken of specimens from five positions on the cross section of each block, as shown in Fig. 1. The small samples cut at the locations indicated were etched with Keller's reagent (0.5% HF, 1.5% HCl, 2.5% HNO_3).

By comparing the micrographs it could be noticed that the chilled block B was less porous, that it had a finer structure, and also that the chill affected the whole block. Castings made in chilled molds were always denser and could stand a higher pressure test; their surfaces were clean and smooth.

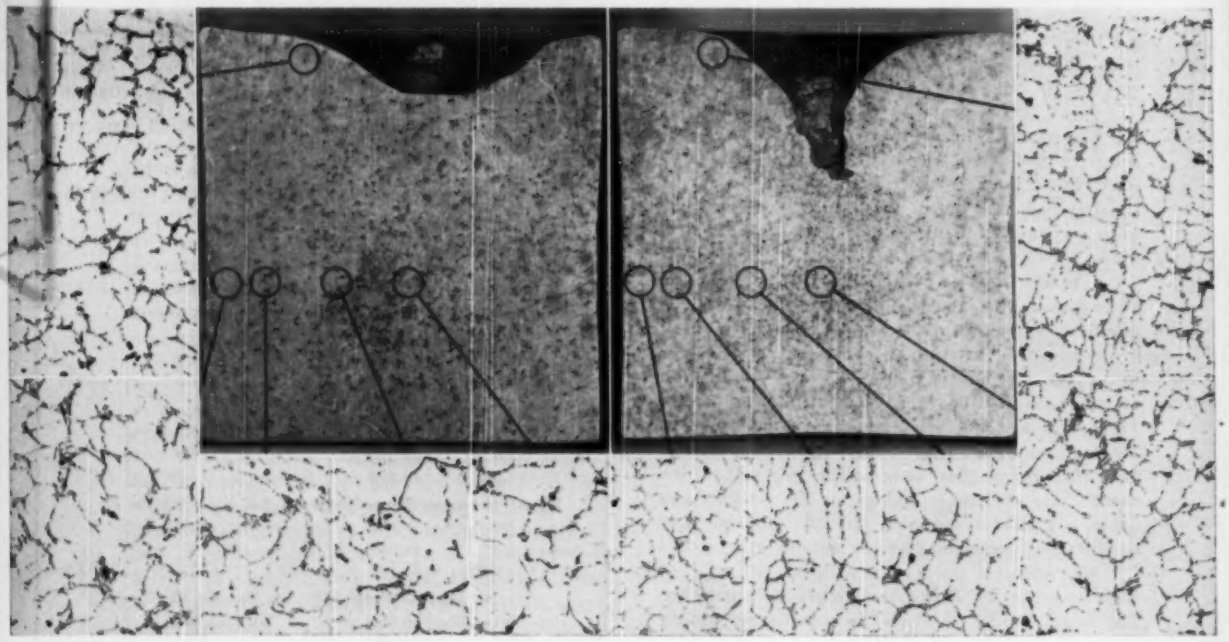
The graphite chilling mixture will not contaminate the molding material after stripping; therefore, separating is unnecessary. The cost of the mixture is low, especially when old broken crucibles are used.

Acknowledgment is due to Carl G. Ackerlind, of the Naval Research Laboratory, for his help in developing the chilling mixture, and to T. L. Stivers and J. Maltz, metallurgists of the Naval Gun Factory, for preparing the samples and examining them microscopically.

Fig. 1 — Structure of Aluminum, 5% Silicon Alloy Cast in Sand (Block A) and in Graphite Molding Mixture (Block B). The blocks are 3 x 3 x 3 in.; micrographs are shown at 55×

Block A — Cast in Sand

Block B — Cast in Graphite Molding Mixture



To conserve columbium, it is important to substitute Type 321 (titanium-stabilized) stainless steel for Type 347 (columbium-stabilized) wherever it can be done without sacrifice in performance. Extensive experience shows no difference in service behavior between Types 321 and 347 in aircraft components operating up to about 1500° F. In fabrication and initial cost, there are definite advantages in using Type 321.

Conservation of Columbium

THE INCREASING DEMAND for columbium as a stabilizing agent for stainless steel and as a strengthening addition for many of the new high-temperature alloys has reduced our national stockpile to an extremely critical level. In the event of war and the consequent acceleration in demand for jet engines the national reserve would probably be exhausted within several weeks. An additional factor contributing to the shortage is the recent reduction in the allocation to this country of the columbium-rich African ores which have been our major source of supply. It is therefore imperative that any application of columbium-bearing alloys be rigidly examined to determine whether alloys containing less strategic materials could be substituted without sacrifice in performance.

By far the greatest tonnage of columbium is used for stabilizing the austenitic stainless steels to prevent loss of corrosion resistance after exposure in the range of about 800 to 1500° F. In this application sufficient columbium is added to combine with the carbon present and prevent its co-precipitation with chromium at the grain boundaries during welding and other periods of exposure in the "sensitizing" range. The amount added must be greater than about eight times the carbon content and is usually less than 1% of the alloy. The most important alloy in this class is A.I.S.I. Type 347, which contains about 18% chromium, 11% nickel, and columbium equal to about ten times the carbon content.

The next largest use for columbium is the comparatively new group of alloys developed primarily for service in gas turbine power plants where high strength is required at temperatures of about 1500°F. In this application columbium in amounts up to about 5% has been found extremely beneficial to high-temperature properties. For example, S-816, a cobalt-base alloy which contains 4% columbium, has been adopted as the standard turbine blading material for the J-33 and J-35 jet engines because of its superior service life at the operating temperatures. Columbium must be available for this class of alloys because no other materials are presently available that can equal their performance in applications at extremely high temperature.

One solution that has been suggested is the increased use of the leaner South American ores containing tantalum as well as columbium. From these ores a ferro-alloy is produced which contains approximately equal amounts of columbium and tantalum. Recent investigations of standard alloys made with this substitute mixture of stabilizing elements have shown that the properties studied in laboratory tests are not appreciably affected. Although there is little information available as to the behavior of the material in service, Aeronautical Material Specifications have recently been amended to permit use of stainless steel stabilized with tantalum and columbium.

By John F. Tyrrell
Research Metallurgist
Solar Aircraft Co.
San Diego, Calif.

An alternate solution which seems obvious but is often overlooked is the use of titanium-stabilized steels such as A.I.S.I. Type 321 in place of columbium-stabilized steels. The behavior of Type 321 stainless is well known, both in fabrication and service. It is true that in some applications, particularly in the chemical process industries, Type 321 is unsatisfactory because of its relatively low resistance to corrosion in specific chemical mediums such as nitric acid. In aircraft, however, there are many components in which both Types 321 and 347 have been used interchangeably without any significant differences in service life. By discouraging the use of Type 347 for such applications a large amount of columbium would be saved; furthermore, significant production economies would be realized, because Type 321 is cheaper, easier to form and often easier to weld.

During the last twenty years Solar Aircraft Co. has manufactured more than 400,000 exhaust manifold sets for aircraft engines. These sets operate in the range 800 to 1500° F., and the vast majority of them were made of stabilized stainless steel, often with A.I.S.I. Types 321 and 347 specified as alternate materials. For units in which Solar Aircraft was permitted to specify the alloy, Type 321 has usually been chosen. The reason for this selection is shown in the following summary of the comparative fabrication characteristics, engineering properties and service behavior of the two steels.

Welding Characteristics

Both alloys have been welded by virtually all production methods and, on equivalent sections, comparative weldability depends essentially on the welding method. In resistance welding, either spot or seam, there is apparently no significant difference between the two steels. Current input and pressure settings are exactly the same for the same gage of sheet. Mechanical properties as measured by tension-shear tests show no difference.

In fusion welding by the inert-gas-shielded arc process, Type 321 (Ti) has been found equal or superior to Type 347 (Cb). The most significant difference is in the rate of welding that can be maintained in production in order to make weldments of consistently high quality. In manual welding by this process, an average welder can produce about 300 in. more per day on welded seams with Type 321 than on equivalent sections of Type 347. A greater disadvantage is the occasional heat of Type 347 in which the welding rate must be decreased to about one third the customary speed in order to prevent weld cracking. Of even more importance is the amount of weld repairing required on Type 347, which averages about five times as much as on Type 321.

In automatic machine welding by the inert-gas process, welding rates for Type 321 average 150% faster than for Type 347 for the type of parts Solar is currently welding. Recent experiments showed that under equivalent welding conditions (admittedly more severe than is advisable for production) about 50% of the Type 347 heats had to be welded at speeds less than 10 in. per min. with extremely close control of current required to prevent cracking. The difference in the two materials seems to be related to variation in chemical composition within the range normally specified and possibly to the content of unspecified minor elements. The exact effect of variation of each of the elements on weldability has not yet been accurately determined.

For weldability tests a flat copper back-up bar with a 0.010 x $\frac{3}{32}$-in. groove is used. The welding

Fig. 1 — Representative Stampings of Titanium-Stabilized (Type 321) and Columbium-Stabilized (Type 347) Stainless Steels, Illustrating Comparative Formability Under the Drop Hammer. This shroud for an exhaust manifold could not be produced from Type 347, but could be formed from Type 321

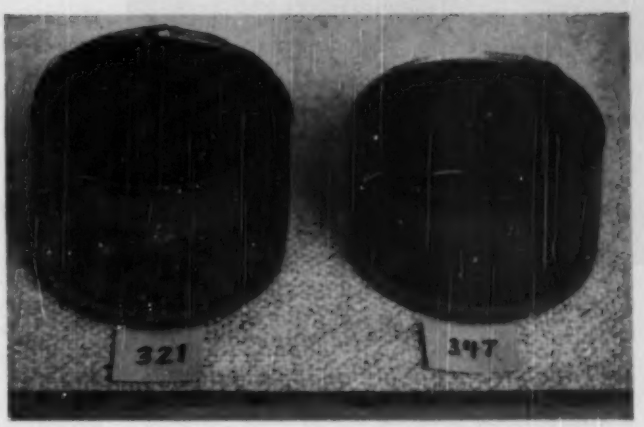


Fig. 2 — Cylindrical Cups Illustrate Maximum Depth of Draw Possible Without Annealing, for Types 321 (Ti) and 347 (Cb)

generator is a General Electric Type W. D. 3150-C and helium gas is used for shielding the arc. Clamping pressure for the standard 0.063 x 6 x 6-in. specimen is 50 psi., which is sufficient to insure no movement of the pieces during welding.

To make a weldability test the machine is set at 25 in. per min. travel speed with just enough current to obtain complete penetration. If cracking occurs in the weld at this setting, the current and travel speed are reduced in steps until a rate of travel is reached that will produce satisfactory welds. If cracking does not occur at 25 in. per min., current and welding speed are increased until cracking does occur or until the top speed of the machine (50 in. per min.) is reached. At 50 in. per min. welds are made with current increasing in 5% steps until cracking occurs or an increase of 25% over the optimum setting is reached. Materials which do not crack in this part of the test are classed as having "good weldability". All of the Type 321 heats and only about one heat in five of the Type 347 are so classified.

In metal-arc welding, the Types 321 and 347 sheet are each welded at the same rate in production. The Type 347 sheet also shows the same tendency to develop "hot short" cracks as in the inert-gas process but the difference in weldability is not so marked, primarily because Type 347 filler rod is used for both alloys. Type 321 rod is not used because the extremely heavy loss of titanium on melting might result in the deposition of an unstabilized weld deposit.

For oxy-acetylene welding, the scheduled production rates of Types 321 and 347 are the same; however, the average speed with Type 321 is actually slightly lower because of an occasional heat which must be oxy-acetylene welded at about half the normal rate. Solar's experience, as reported by F. H. Page,[1] is that the poor weldability has been due primarily to silicon content below 0.50%. Most of the stainless steel producers now furnish Type 321 with silicon content in the range 0.50 to 0.75% so that the occurrence of material with poor weldability is not so prevalent as it used to be.

[1]References are on p. 68.

Another factor that affects gas weldability is the flame adjustment used by the operator. Type 321 should be welded with a flame as nearly neutral as can be maintained, whereas Type 347 is normally welded with a more reducing flame. Much of the difficulty reported in the welding of Type 321 seems to be due to improper flame adjustment rather than any deficiency in the alloy.

Forming

One of the major considerations in the design of aircraft components is the problem of obtaining maximum thickness of section with a minimum of weight. In order to accomplish this on the complex stampings required in exhaust manifolds, it is necessary to place a limit on the amount of localized thinning permissible during the forming operations. At Solar Aircraft, the maximum thinning acceptable is 30% of the initial thickness and is usually held to less than 20%. For complex stampings, it has been found that the rate of rejection for excessive thinning is approximately twice as much for Type 347 (Cb) as for Type 321 (Ti). In addition, there have been many stampings that could not be produced from the columbium-stabilized grade but were formed successfully from Type 321. For example, Fig. 1 shows typical stampings of the front shroud for the Lockheed P-38 exhaust manifold. It could not be produced from Type 347 as originally required, but could be formed from Type 321.

An extensive investigation[2] conducted recently showed that Type 321 can be deformed about 5% more than Type 347 before localized thinning occurs in drop hammer forming. In deep drawing operations Type 321 can be drawn about 10% more than Type 347, as shown in Fig. 2.

Fig. 3 — Small Aircraft Components Cast Successfully From Type 321 Stainless Steel. Mechanical properties are comparable to those obtained with Type 347 stainless

Sand Casting

Castings of stabilized stainless steel are almost invariably made from Type 347 because of the loss of titanium from the molten steel. Several experimental heats of Type 321 have been made at Solar Aircraft Co., and the results indicate that successful castings can be produced if some modifications are made in the alloying practice to offset the high titanium loss. Large castings can be made without too much difficulty by making alloy additions in the ladle. With the time required to pour small complex castings, however, the "fading" of the titanium content has resulted in a marked composition variation between the first and last casting poured. Solar's practice has been modified so that successful Type 321 castings have been made of the small units shown in Fig. 3. The chemical composition and mechanical properties of the casting were comparable to those obtained with Type 347, as shown below:

C	Mn	P	S	Si	Cr	Ni	Ti
0.044	1.15	0.014	0.005	0.92	20.05	9.36	0.24

Y.S.	T.S.	R.A.	Elongation
37,500	79,000	54%	53% (2 in.)
42,000	77,500	61	58
38,000	77,500	63	57

Engineering Properties

The major engineering properties on which design is based are the load-carrying ability at the service temperatures, the thermal expansion characteristics, density, thermal conductivity and resistance to corrosive attack in the service environment. At temperatures less than about 800° F. the load-carrying ability is designed around the yield strength or tensile strength, as creep is not a significant factor in these alloys in this range. Figure 4 shows the average tensile strength of coupons cut from bar stock of each of the alloys, between room temperature and 1500° F., as reported by a number of different laboratories.[3-8]

Comparative data on sheet stock are not so readily available, but tests have recently been conducted at Solar for selected heats representative of material currently being furnished by the major stainless steel producers (Tables I and II). It is apparent that the difference is not significant and that Type 321 or Type 347 sheet could be used interchangeably in this range if strength were the sole determining factor in selection.

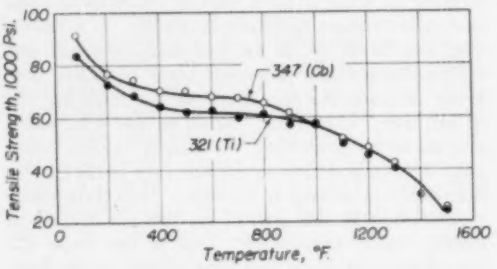


Fig. 4 — Comparison of Tensile Strengths of Types 321 and 347 Bar Stock at Elevated Temperatures. Each point represents the average of data reported by several different laboratories (Ref. 3 to 8)

Creep — Above 800° F. the load-carrying ability for design purposes is based on resistance to creep. For short periods of time and lower temperatures Type 347 is generally reported to be slightly superior to Type 321. However, the scatter of results obtained from samples of the same type of material indicates that this difference may be insignifi-

Table I — Compositions of Sheet Specimens Used in Short-Time Tensile Tests

Type	Heat	C	Mn	P	S	Si	Cr	Ni	Ti	Cb
321	A	0.07	1.40	0.023	0.008	0.52	17.12	10.82	0.58	—
321	B	0.05	1.48	0.027	0.010	0.58	18.32	10.18	0.38	—
321	C	0.06	1.57	0.023	0.016	0.62	17.56	10.54	0.45	—
347	D	0.06	1.72	0.024	0.009	0.22	17.88	11.68	—	0.72
347	E	0.05	1.78	0.022	0.010	0.58	17.50	11.35	—	0.91
347	F	0.04	1.25	0.015	0.006	0.42	17.60	10.95	—	0.53

cant for design purposes. Comparative creep strengths as reported by five different reliable sources[2, 4, 5, 9, 10] are listed in Table III. The wide range reported for different samples of the same alloy indicates that any difference between Types 347 and 321 is probably insignificant.

Other factors of major importance in determining suitability for service in aircraft components operating in this range are density, thermal expansion, thermal conductivity, and resistance to oxidation and carburization. There is no measurable difference between the two alloys in the first three properties; however, limited data available indicate that Type 321 is about 50% more resistant than Type 347 to oxidation and oxidation plus carburization at 1300° F.[11] The rate of attack is low, however, and the service life of aircraft components should not be affected appreciably.

Oxidation — Above 1500° F. the strength of both alloys decreases rapidly and their applications should be limited to units in which stresses are extremely low. The primary consideration in selection of the proper alloy is the relative resistance to oxidation. Tests conducted at Solar have shown that Type 321 is about twice as resistant to oxidation at 1850° F. as Type 347 in 400 hr. of exposure. The difference is even greater for short periods of exposure as shown in Fig. 5. These data were obtained on samples exposed to the atmosphere in an electric furnace for 25 periods of 16 hr. at temperature followed by 8 hr. at room temperature.

Chemical Composition

The substitution of Type 321 for 347 would save not only the columbium but a significant amount of nickel, which also would be a critical alloying element in an emergency. In addition a small saving of manganese would be obtained, as indicated by the results of a statistical analysis of the chemical composition of all Types 321 and 347 sheet stock received by Solar in 1949 from the major stainless steel producers. The average analyses for the two alloys were found to be:

Alloy	No. of Heats	C	Mn	Si	Cr	Ni	
321	77	0.055	1.35	0.58	17.85	10.11	0.51 Ti
347	87	0.054	1.57	0.50	18.01	11.25	0.78 Cb

It is interesting to note that the average heat of Type 321 contains about 140% more titanium than is necessary to stabilize the carbon present, while the Type 347 contains about 85% more columbium than the minimum theoretical requirement.

The content of minor elements has not been studied as completely but spot checks indicate that

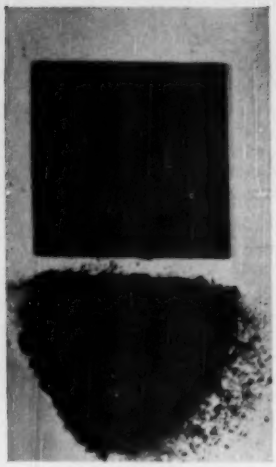
Table II — Comparison of Tensile Strength and Elongation of Sheet Specimens at Elevated Temperatures

For compositions, see Table I

Type 321 (Ti)			Type 347 (Cb)		
No.	Tensile	Elong.	No.	Tensile	Elong.
Tested at Room Temperature					
A-1	88,200	47%	D-1	87,700	45%
A-2	88,000	47	D-2	86,600	45
B-1	89,200	48	E-1	85,600	47
B-2	89,200	49	E-2	85,600	47
C-1	90,300	48	F-1	91,700	43
C-2	91,000	48	F-2	92,700	44
Avg.	89,300	47.8	Avg.	88,300	45.2
Tested at 400° F.					
A-3	67,800	36	D-3	67,500	34
A-4	68,500	36	D-4	67,500	34
B-3	67,700	37	E-3	66,000	32
B-4	68,100	37	E-4	66,800	33
C-3	68,300	38	F-3	68,800	35
C-4	68,600	38	F-4	69,200	34
Avg.	68,200	37.0	Avg.	67,600	33.7
Tested at 600° F.					
A-5	65,100	30	D-5	64,800	28
A-6	65,900	32	D-6	65,000	29
B-5	67,500	35	E-5	63,500	30
B-6	67,000	33	E-6	63,900	30
C-5	66,200	33	F-5	65,800	30
C-6	66,400	33	F-6	65,600	28
Avg.	66,400	32.7	Avg.	64,800	29.2
Tested at 800° F.					
A-7	64,100	31	D-7	63,800	33
A-8	63,900	28	D-8	63,600	28
B-7	65,700	33	E-7	61,900	27
B-8	65,700	33	E-8	62,300	32
C-7	64,800	31	F-7	63,200	32
C-8	64,700	32	F-8	64,200	30
Avg.	64,800	31.3	Avg.	63,200	30.3
Tested at 1000° F.					
A-9	58,700	30	D-9	60,800	24
A-10	58,500	27	D-10	59,900	29
B-9	61,000	31	E-9	59,100	26
B-10	61,300	30	E-10	58,900	26
C-9	60,700	30	F-9	59,300	22
C-10	60,500	31	F-10	59,900	26
Avg.	60,100	29.8	Avg.	59,700	25.5

Table III — Initial Stress to Produce Creep Rate of 0.0001% Per Hr.

Temperature	Type	Average Value	Range Reported
1100° F.	321	15,800 psi.	12,800-21,000 psi.
1100	347	18,500	13,500-27,000
1300	321	7,900	4,500-12,500
1300	347	7,400	4,600-16,000
1500	321	3,600	750-10,000
1500	347	3,800	1,000-11,200



Type 347
Wt. Loss, 2.335 g.

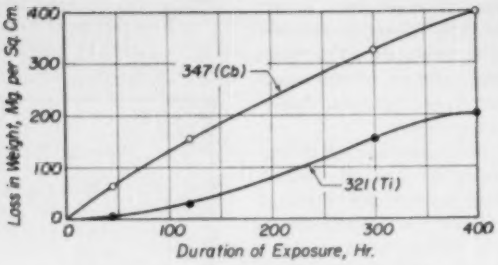


Fig. 5 — Curves Show Oxidation Characteristics as a Function of Total Duration of Exposure. Specimens at sides illustrate scaling losses after 64 hr. intermittent exposure at 1850° F.

Type 321
Wt. Loss, 0.265 g.

the only other significant differences in composition are that Type 321 contains approximately one third as much nitrogen and about 50% more phosphorus than the Type 347 material.

Service Behavior

The engineering properties summarized above indicate that there should be no significant difference in service behavior between the two alloys. Solar's experience has indicated that the titanium-stabilized alloy will give satisfactory performance in reciprocating engine exhaust systems, jet tailpipes, exhaust cones, aft frames, outer combustion chambers and other parts operating under about 1500° F. For example, at least six engine sets on the DC-4 exhaust system, constructed by Solar from Type 321 material, have completed over 3000 hr. of service in an application for which the guaranteed life is 300 hr.

The original B-29 exhaust system was fabricated from Type 347 and did not have a satisfactory service life. Later the system was redesigned by Solar and both Types 321 and 347 were used with satisfactory service life. The improvement was, of course, due to the changes in design; however, the case history does indicate that Type 321 can be used in critical components under severe operating conditions.

Summary and Conclusions

Columbium is in critical supply and it appears that much of it will have to be diverted from its use as a stabilizing agent for stainless steel to the high-temperature alloys required for turbine blades in jet engines. Two methods have been suggested to alleviate the situation: One is to replace all columbium-bearing stainless by new alloys containing additions of tantalum plus columbium in equivalent amounts; the other is to encourage the use of titanium-stabilized steels.

Comparison of the properties of titanium and columbium-stabilized steels indicates that except for specific corrosive environments there is no significant difference in engineering properties between the two materials. In aircraft and jet engine components operating at temperatures up to about 1500° F. there appears to be no difference in service behavior between Types 321 and 347. In fabrication characteristics and initial cost, there are definite advantages for Type 321.

References

1. "Chemical Factors Affecting the Welding Properties of Stabilized 18-8 Stainless Steel", by F. H. Page, *Welding Journal*, V. 24, 1945, p. 929.

2. "Formability of Alloys for Elevated Temperature Service", by J. F. Tyrrell, *Transactions*, American Society for Metals, V. 42, 1950, p. 405.

3. "Wrought Heat Resisting Alloys", Metals Handbook, American Society for Metals, 1948, p. 562.

4. "Steels for Elevated Temperature Service", United States Steel Corp., 1949, p. 62.

5. "Allegheny Metal 18-8C and 18-8T", Allegheny Ludlum Steel Corp.

6. "Digest of Steels for High Temperature Service", Timken Roller Bearing Co., 5th Edition, 1946, p. 189.

7. "Stainless Steel Handbook", Eastern Stainless Steel Corp., 1st Edition, 1945, p. 85.

8. "Rezistal 321 and Rezistal 347", Crucible Steel Co., Data Sheets, August 1947.

9. "Creep and Rupture of Several Chromium-Nickel Austenitic Stainless Steels", by G. V. Smith, E. J. Dulis and E. G. Houston, *Transactions*, American Society for Metals, V. 42, 1950, p. 935.

10. Private Communication from G. F. Comstock.

11. "High Temperature Corrosion of Metals Under Alternate Carburization and Oxidation", by H. K. Ihrig, *Transactions*, Electrochemical Society, V. 91, 1947.

The Burlington Road's Denver Zephyr, the pioneering high-speed streamliner, a structure made of stainless steel trusses and sheathing, proves absolutely sound after mileage of 4,500,000

Stainless Passenger Equipment

Untouched by 13 Years

THE FIRST of the high-speed trains popularly known as "streamliners" was put into operation by the Burlington Route in October 1934 on a 502-mile daily round trip between Lincoln and Kansas City. It was an instant success. Patronage doubled, operating costs were cut in two, profit jumped from $36 a day for the old heavy steam train to $440 a day for the new lightweight one. Consequently two much more elaborate trains were built in 1936 and put in service, running in opposite directions between Chicago and Denver, making the 1037-mile journey between 4:00 P.M. and 9:00 the next morning. The time had been cut from 26 hr. to 16 hr., the average speed increased from 40 miles per hr. to 65.

E. J. W. Ragsdale, research engineer for Edward G. Budd Mfg. Co. (now The Budd Co.) of Philadelphia, the builder, described the construction of these Burlington "Zephyrs" in Chapter 21-E of "The Book of Stainless Steels". Each car is a large tubular beam with members fabricated of cold rolled 18-8 steel sheet and strip; the roof is the main compression member, the floor is the main tension member, the shear is taken by the trussed side skeleton. (The side sheathing is merely a covering.) Every detail was most carefully designed; the roof, for example, is of corrugated 0.022-in. metal, yet a man can walk on it safely. All joining was by Budd's exclusive "shotweld" process (spot welding under rigidly controlled conditions to limit size of weld nugget).

As Ralph Budd, then president of the Burlington Lines, said: "Such a train could not have been built without advanced metallurgy as typified by 18-8 sheet, cromansil welded engine frames, roller bearings, lightweight diesel engine, and crumpled aluminum insulation." Economics indicated, indeed, that something radical was necessary to justify the substitution of stainless at 45¢ per lb. against carbon steel at 3¢. (1934 prices sound remarkable, don't they?) Ragsdale put it this way: "Even granting that stainless is three times as strong as carbon steel and therefore needs only one third the weight, the greatest portion of the saving comes in the power plant. Train performance is a function of motive horsepower per ton, and the diesel-electric plant ordinarily installed costs about $100 per hp. In trains made of stainless steel, such as the well-known Burlington 'Zephyr', the rating is 6 hp. per ton of light train weight. This brings the cost of the initial investment in power plant up 30¢ for every pound of train. Stated in another way, stainless steel plus power plant to haul it costs 45¢ plus 30¢ or 75¢ a lb. Equivalent carbon steel plus power to haul it costs 3(3+30) or 99¢.

"Then, finally, it is surprising to learn that in the stainless steel 'Zephyr' weighing 208,000 lb., only 46,000 lb. of stainless was used; 22% by weight and 8% by cost.

"The fight against needless weight cannot be confined to the structure of the car body alone. It must be carried into every department. Conventionally built passenger cars give, roughly, one

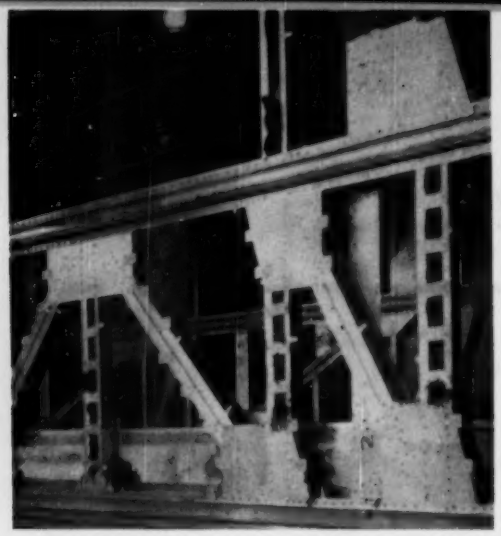


Fig. 1 — May 1936, in Budd's Philadelphia Plant; Outside View of Side Truss Members on One Car for the Denver Zephyrs. Shot welded construction of 18-8 strip, cold drawn to 150,000-psi. tensile strength

Fig. 2 — October 1949, in Burlington's Aurora Shops, 13 Years and 4,500,000 Miles Later; "Indistinguishable From New Construction". (Inside view)

third the total weight each to car body, appointments and trucks. Approximately this same proportion obtains in the case of lightweight trains, exclusive of the power plant.

"Reduced weight of appointments reduces in turn the body structure, and both reduce the required truck weight. Since trucks remain more or less conventional, saving is accomplished chiefly by articulated trains, wherein adjoining car ends are pivoted over a common truck. Thus, three cars employ four trucks instead of six."

Such was the original conception. In operation, the trains were instant successes. The era of high speed railroad transportation had come. Railroads all over America quickly followed suit. Streamliners are now no novelty. Their speed, air-conditioned comfort, safety and economy have brought passengers back to the rails, and have been major factors in withstanding competition by automobile, bus and airplane.

But to the railroad man the most revolutionary of all the items was the construction of a car with undiminished strength, made of steel only a few hundredths of an inch thick — paper thin. Could it endure? The final answer came a few months ago when these trains, each a veteran of more than 4,500,000 miles of travel, were run into the Aurora shops, and stripped for inspection, reconditioning, and redecoration. This was their first major overhaul. The "Denver Zephyrs" still looked bright and shiny on the outside; how about the hidden members, the basic structure?

There was no evidence of corrosion of any of the stainless steel members at any place. The shot welds when first made are marked by slightly bronzed spots from the welding heat. This quite superficial oxidation was somewhat intensified in color, but still represented an infinitesimal amount of metal. The smudge of dirt accumulated in 13 years was easily rubbed off, leaving metal bright, smooth and shiny as ever.

In contrast, carbon steel details, such as filler strips, partitions, conduit and junction boxes, were so badly corroded as to need complete replacement. Stainless steel water tanks were reinstalled after inside and outside cleaning; there was nothing the matter with them. H. Urbach, general superintendent of motive power and machinery of the Burlington Lines, writes, "There was no way of telling the basic structure from new construction." Only two small cracks were found in door sills in the baggage car — but can *anything* withstand the baggage smasher?

New glass-wool insulation was compressed into all spaces in the outer walls, the floors raised 2½ in. to give better visibility from side windows, kitchens modernized with automatic equipment (stainless, of course), draft gear parts rebuilt or replaced to take up slack, trucks dismantled and re-erected, roll stabilizers (shock absorbers) installed. Also the old paint in the interior was stripped off and a complete job of redecorating and re-upholstering done. Again to quote Mr. Urbach, "We now have two new trains, just as modern by today's standards as they were on the first day they started operation, at a fraction of the cost if bought now."

The Budd Co., long claiming that "No Budd car has ever worn out," now adds: "These cars approach what has always been considered an engineering impossibility — a *permanent* structure." (A pardonable short-range extrapolation!)

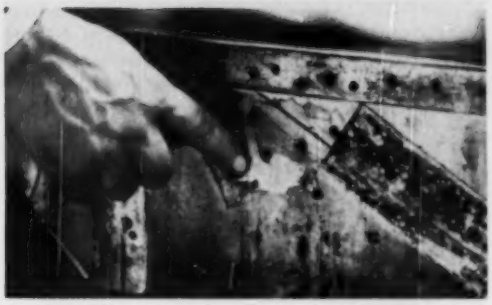


Fig. 3 — A Rub of the Finger, Off Comes the Smudge. Underneath is bright stainless

Heating Diesel-Powered Passenger Trains

By E. A. Russell
Vice-President, Engineering
Vapor Heating Corp., Chicago

WHEN TRAINS were hauled by steam engines there was usually enough steam for handling and heating of the cars. Steam from the locomotive is directed into a trainline under the cars, automatic valves reduce the steam pressure and thermostats control the amount entering the fin radiators in the cars. But now-a-days, with diesel locomotives, a very special type of oil-burning steam generator is installed. Standard equipment for this duty is the compact "Vapor" steam generator, notable not only for its small size (6 x 4 x 6½ ft.) but the wide range of modern metals and alloys used in its construction. These units can get up full steam pressure in two minutes from cold water and a medium size one evaporates ½ to 1½ tons of water per hr. Two of these can be installed in one diesel and heat a 14-car train in a Nebraska winter. Heat is liberated in the firebox of these generators at an extraordinary rate, comparable to a jet engine, but used so efficiently they operate at over 80% efficiency.

Examination of the wash drawing Fig. 4 and its caption will indicate the interrelation between metallurgy and passenger comfort. One electric motor supplies the ignition spark, drives the fuel pump, the blower for combustion air, and the water pump. Fuel oil is atomized by compressed air, and meets a swirling rush of combustion air. The fire pot is of welded 16-gage Inconel sheet; the triple-wall construction forms a double jacket through which the combustion air travels, getting preheated and simultaneously keeping the temperature of the inner pot down to a safe 1000 to 1200° F. The lower part of the firebox is lined with molded silica refractory tiles.

This swirling flame then works outwardly through the three banks of water tubes. (The drawing gives the erroneous impression that a crimped diaphragm separates successive coils; really these are short stainless steel sinuous strips, spot welded to a tube on one end only, and insure proper spacing, tube to tube, irrespective of temperature.) Passing upward, the flue gas contacts a fourth coil of tubes *K*, the economizer, containing the water entering the system. (Water and flue gas move counter-current.) This coil is made so it can be readily replaced, because most of the corrosion occurs in this place — internal pitting as the cool feed water gives up its dissolved oxygen, and external corrosion from acidic condensate from the stack gases.

The water tubes are of seamless carbon steel boiler tubes, 1¼ to ¾ in. internal diameter, welded end to end in straight runs before coiling over drums. After complete fabrication, the set is stress relieved for 6 hr. at 1150° F., and tested hydraulically at 1200 psi. (Operation is at 300 psi.)

In a unit which evaporates so much water as this, the problem of boiler scale immediately comes to mind. This is avoided by three means. In the first place the water supply is treated chemically to prevent it from forming an adherent scale; the solids come down as a granular sludge. In the second place, the flow of water and the evaporation rate are balanced so the heater produces a wet steam — 95% steam, 5% water. In the third place, a steam separator by swirling action then delivers practically dry steam to the trainline, and a sludgy liquid to the sump from which most of the water is returned to the supply tank, and the muddy solids blown off automatically at proper intervals.

Since the device is completely automatic, a rather large group of special alloys are used — for example, nichrome wire in the ignition electrodes; stainless steel bodies, seats and springs on safety and stop valves; starting resistors and relays with magnetic iron frames, nickel-silver arms with tungsten contactors; gage snubbers of porous bronze, a powder metal part to absorb pulsations; servo-controls of corrosion resistant metals throughout, like stainless and monel; sludge blowdown valve and seat of stellite to resist scour;

temperature limit controls of bi-metals. In the oil burner, the spray nozzle tip is of hardened stainless steel, and the flame stabilizing cone is a 28% Cr, 8% Ni casting. Copper, bronze and brass are the principal metals in pipe and fittings in contact with wet steam.

Aside from the more-or-less conventional irons and steels (cast iron pump bodies, steel cabinet, forged shafting, seamless tubes, spring steel) there are no less than 24 special alloys in the mechanical auxiliaries, to say nothing of an unnumbered group in the electrical controls and interlocks bought complete from outside sources. Truly it takes modern metallurgy to make the streamliner *go!*

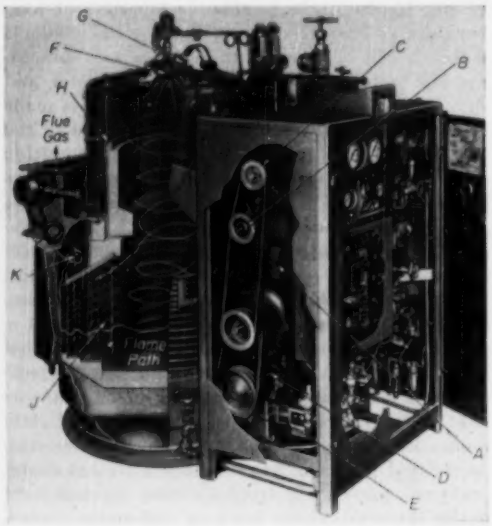


Fig. 4 — Phantom Drawing of Steam Generator for a Diesel-Powered Streamliner. (Courtesy Vapor Heating Corp.) A list of principal units and metals therein follows:

A — Starting resistor: nichrome
B — Belt tension adjuster;
Aluminum sheaves, spring steel
C — Blower; stainless steel ball bearings
D — Oil fuel pump; cast iron body
E — Water pump; aluminum casing, bronze head
Cast steel crankshaft
Stainless steel plungers
Meehanite cast iron gears
Naval brass packing sleeves
Everdur fittings
F — Oil nozzle, bronze
Hardened stainless steel tips
Cast 28:8 Cr:Ni flame cone
Nichrome ignition electrodes
H — Fire pot; Inconel
J — Water coils; seamless, carbon steel
Stainless steel spacers
K — Economizer; seamless carbon steel tube

Correspondence

Test Bar Results Compared With Tests on Components

BOSTON

In his article in the March issue of *Metal Progress*, A. L. Boegehold has reached the conclusion that test results on specimens are unsuitable as a means of forecasting service performance. On the basis of our past experience we agree with this general conclusion and, in the light of the data presented, should like to add some amplification on this issue.

Reporting fatigue strength for test bars is a relatively straightforward matter. Methods of testing and terminology for expressing results are fairly standard and results are therefore readily interpreted by the engineer and the metallurgist. The same is not true for the fatigue testing of components; results are a function of the particular test setup, and terms used in presenting results are a matter of choice to the test engineer. For these reasons alone, any correlation between tests on specimens and components becomes an oversimplification unless the details of component testing, or interpretations of their effects, are reported.

In Mr. Boegehold's article, no mention was made of the device used in testing crankshafts. It may be presumed that the shafts were tested in either uniform or cantilever plane bending. At any rate, the geometry of the load system will influence the test failure pattern, particularly the location of the point of incipient failure. In turn, crankshaft fatigue strength will be quantitatively affected. For a more complete understanding of the value obtained, information on stress distribution during the test should be supplied.

Mr. Boegehold has reported crankshaft fatigue strength in pounds per square inch. Prior to analysis it should be made clear what the reported crankshaft stress represents — nominal stress or peak fillet stress, measured or calculated stress, pin, journal or web stress. Numerically, fatigue

strength is primarily a function of the terms in which it is expressed. As an example we quote the following result of a bending fatigue test on a drop forged diesel crankshaft:

In Terms of:	Fatigue Limit
Max. Pin Fillet Stress	49,000 psi.
Max. Journal Fillet Stress	41,800
Pin Stress Adjacent to Fillet	19,000
Pin Stress Midway Between Webs	7,000

(Stresses were measured during the fatigue test by wire gages and later checked by photoelasticity.)

While an understanding of the component test is fundamental to a correlation with the specimen test, such understanding complicates rather than solves the problem. Any analysis of data is now beyond the realm of evaluating (for the two test methods involved) primary effects of metallurgy and processing, and consideration must be given to secondary effects involving:

1. Notch sensitivity of the material.
2. Size effect in fatigue.
3. Exact location of failure zone in the test specimen referred back to the crankshaft from which the specimen was cut.
4. Flow line pattern at the point of failure of test specimen, compared with flow line pattern at the point of failure of crankshaft.
5. Mode of testing (rotary or plane bending).
6. Surface finish of test specimens, compared with that of the crankshaft.

With these complications it becomes impractical and unreliable to investigate crankshaft strength through fatigue bar tests and, as was implied by Mr. Boegehold, recourse must be taken in component testing.

It has been our experience that from the point of view of industrial research, it can be exceedingly dangerous to draw final conclusions from any comparison involving either two types of laboratory test or a laboratory test and service conditions. There always exists the danger of the two experiments not paralleling each other, either along lines for which such parallelism has been taken for granted or in a manner too obscure to be recognized. Each of the two types of test can be applied most reliably singly for evaluating relative merits of several materials or processes.

Effect of Flow Line Orientation on Fatigue Strength — Figure 7 of the subject paper indicates the marked difference in fatigue strength between longitudinal and transverse test bars cut from cylindrical forgings. While this effect exists, the increased strength exhibited by the longitudinal specimens may be attributable partly to the fact that the longitudinal specimens were taken from the outer fibers of the forging, whereas the transverse specimens were cut from the center of the forging. It is the writer's opinion that, for a true evaluation of the flow line effect, both types of specimen should have been taken from the same region of the forging.

Nonuniformity in Drop Forged Crankshafts — In Fig. 8 the scatter obtained in testing transverse specimens cut from many drop forged crankshafts is illustrated. The implied nonuniformity is nonuniformity of specimen fatigue strength, not necessarily of crankshaft fatigue strength. Considering the macrograph of the crankshaft showing the location of the test specimens within the shaft, it will be seen that flow line orientation changes continuously throughout the region set aside for test bars. Thus any slight variation in location of critical section of the test specimens will contribute to the apparent scatter.

In this connection, it is interesting to note that, of some 180 test points plotted, only 19, or roughly 10%, fall outside a scatter band that is by no means unacceptable for fatigue testing. Were all fatigue limit determinations carried out with 180 specimens, some of the specimens could be expected (from the statistician's point of view) to give results which are out of line, regardless of the material, production process or test method involved.

Quantitative Effect of Residual Stress on Fatigue Strength — In evaluating "true core fatigue strength" of nitrided bars, Mr. Boegehold has resorted to the expedient of combining arithmetically the calculated residual stress with the fatigue limit of the nitrided specimen. Such procedure is in contradiction to currently accepted theories on combined static and dynamic stress, of which the simplest is expressed in the familiar Goodman diagram.

Fatigue Strength of Nitrided 4340 Steel — Table IV of the paper reports results obtained with nitrided 4340 steel as found in actual crankshafts and in longitudinal and transverse R. R. Moore test bars.

For the crankshaft, residual stresses have been computed on the basis of calculations carried out for cylindrical bars. We do not believe that residual stresses can be computed for the point of failure of the actual crankshaft. The geometry of such a shaft at the transition from web to journal or pin is such that even an experimental determination of residual stresses becomes exceedingly difficult.

As regards the "fatigue limit stress due to externally applied load", this figure is subject to the arguments presented in the first part of this letter; without further knowledge of the actual test it has little significance as an absolute value. However, it is interesting to note that, in whatever terms crankshaft fatigue strength has been

reported, this strength has been increased some 60% by nitriding. For evaluating the increase, the stress concentration factor for the point of failure should be known, as there exists some evidence implying that the strengthening caused by nitriding consists chiefly of an obliteration of the effect of notches — that is, nitriding reduces notch sensitivity to zero. Any additional data on this point would be of considerable importance.

The calculated residual stress and the aforementioned crankshaft fatigue strength have then been combined to yield the "true fatigue limit" of the core. For the reasons stated, this figure is believed to be both inaccurate and of slight significance.

For the test bar results in Table IV also the "true fatigue limit" has been obtained by an arithmetic addition of experimentally determined fatigue limits and calculated residual stresses. The order of magnitude of the resulting discrepancy, as referred to results obtained using the Goodman relationship, can be seen from the following comparison of true fatigue limits for test bars with axial flow lines:

By Table IV	115,000 psi.
By Goodman Relationship	105,000
(Determined utilizing a value of 155,000 psi. for tensile strength.)	

On the basis of the preceding arguments, it is seriously doubted that some of the conclusions drawn from the tests are justified. It is also believed that the coining of a term such as true fatigue limit (the fatigue limit of a nitrided specimen corrected for the residual stress) can be very misleading. This term represents a fictitious quantity, which for validity depends on an assumption that has not been proved: that the only effect of nitriding on the dynamic strength of steel is that produced by the residual stress distribution set up through the process.

H. J. Maier
Project Engineer
Lessells and Associates, Inc.

Mr. Boegehold's Reply

Mr. Maier has asked for more information concerning methods used for testing crankshafts, and has confirmed our conclusion that component and test bar results are not comparable because of the many factors present in tests on components that are not present in tests on test bars.

The distribution of stress in the various parts of the crankshafts, according to our thinking, has no important bearing on the fatigue limit of the material at the point of failure. Mr. Maier's table, giving a fatigue limit of 7000 psi. at some place in the pin where fatigue failure does not occur, seems to have little relation to the question.

The crankshafts discussed in the paper were tested in plane bending, and the stresses given for fatigue tests shown in Fig. 5 were determined at the exact $\frac{1}{16}$ in. where fatigue failure began — that is, in the fillet between the journal and web. The stress was determined by means of a strain gage capable of measuring strain between gage marks $\frac{1}{16}$ in. apart. The stresses for the fatigue limit, therefore, are actually measured, as are the stresses given for the test bars, in which the stresses were both calculated and measured by means of the same strain gage. The values in Fig. 5 then are not nominal stress, measured or calculated, pin, journal or web stress. They are values for actual fillet stresses at the location where fatigue failure takes place.

Our experience gained in drawing conclusions from laboratory component testing as a means of selecting materials and heat treatments for the components to be then tested under service conditions has never been associated with any element of danger. As a matter of fact, this process has produced excellent results. It is now generally taken for granted that laboratory tests, to be useful, must correlate with service tests. Therefore, we do not agree with Mr. Maier's statement that "each of the two types of test can be applied most reliably singly for evaluating merits of several materials or processes".

Effect of Flow Line Orientation on Fatigue Strength — The increased strength exhibited by the longitudinal specimens was not partly the result of the specimens being taken from the outer fibers of the forging. Similar tests made on specimens cut from 5¼-in. square stock which permitted transverse specimens to be cut from near the surface showed just as much difference in fatigue limit as when compared with longitudinal specimens cut from near the center of the 5¼-in. square section. These tests were made on both transverse and longitudinal specimens taken from the surface, center, and midway between the surface and center. As a matter of fact, the greatest difference between longitudinal and transverse properties occurred not at the center but halfway beween surface and center.

Nonuniformity in Drop Forged Crankshafts — The statistician's viewpoint which regards everything as normal, uniform, and satisfactory, even when 10% of the points are considerably out of line, is not one that would promote safety of automotive vehicles. It is assumed that Mr. Maier refers to the 19 points on the low side of the band in Fig. 8. In service performance we do not disregard the small percentage of results that fall on the low

side of the expected band. In fact, those are the ones that control our whole attitude and efforts. Contrary to the statistician's attitude, we regard only minimum values as being significant for indicating frequency of expected failures.

Quantitative Effect of Residual Stress on Fatigue Strength — The arithmetic combination of calculated residual stress with the fatigue limit of nitrided specimens is merely an approximation to indicate that the material below the surface withstood higher stresses than indicated by the nominal surface stress. The Goodman diagram is another method of approximation but were the Goodman diagram figures used instead, the conclusion is still the same — specifically, that the material, clad with a nitrided case, endures considerably higher stress than is indicated by the nominal surface stress. Having seen how far from actual facts can be the figures obtained by calculating from a formula, I lose some confidence in the Goodman diagram as a more accurate approximation than the simple arithmetic method.

Fatigue Strength of Nitrided 4340 Steel — Again, the assumption that the residual stress in the crankshaft core just below the nitrided case is similar to that calculated for a cylindrical shaft is another approximation, which merely indicates the direction of component stresses. Regardless of the precision of stress determination, the conclusion is still obvious that the increased resistance to fatigue is the result of compressive stresses in the nitrided case preventing failure from occurring any place in the nitrided case. It is true that, as Mr. Maier says, an exact evaluation of the stress responsible for failure should include the effect of stress concentration. At a point 0.015 in. below the surface of the fillet between cheek and journal there would still be some stress increase due to the stress-raising effect of the fillet. The total stress, therefore, would be higher than at a similar distance below the surface in a cylindrical specimen so that an approximation of stress based on a cylindrical member would be on the conservative side.

The question as to whether the inherent fatigue resistance of the nitrided case is partly responsible for failure originating at a point not within the case was not settled. We know, however, from other tests that when the core of a nitrided test specimen is too small to maintain compressive stress in the nitrided case, failure occurs in the case itself at relatively low stress, showing that the inherent fatigue resistance of the nitrided structure is not appreciably greater than that of the core material. That is the evidence which convinces us that compressive stress must be present in the nitrided case to obtain the high fatigue resistance exhibited by nitrided crankshafts.

Residual Stresses in Chromium-Plated Steel

WASHINGTON, D. C.

In his recent articles in *Metal Progress* [February and March], A. L. Boegehold demonstrated that tempering a quenched steel does not always decrease the residual stress, but may increase it. A similar effect may be obtained in the chromium plating on steel when it is "baked" to expel hydrogen that is deposited with the chromium.

Recent tests at the National Bureau of Standards have shown that the fatigue limits of steel specimens heated after plating first decrease and then increase with increased baking temperature, as shown in Fig. 1. The decrease in fatigue limit

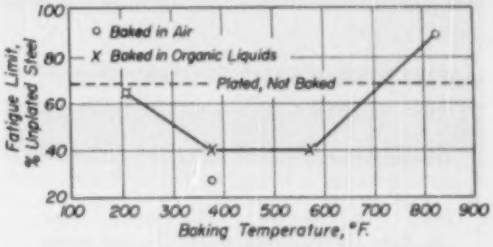


Fig. 1 — Effect of Baking Temperature on the Fatigue Limit of Chromium-Plated X4130 Steel

was correlated with increased tensile stresses induced in the chromium plate by low-temperature baking.

In order to show the presence of tensile stresses in electrodeposited chromium and the effect of baking on these stresses, thin-walled tubes of annealed steel were chromium plated and subsequently heated to different temperatures. "Tongues" — strips about $\frac{3}{16}$ in. wide and 2 in. long, with one end left attached — were then cut in the tubing (Fig. 2) to permit a qualitative evaluation of stresses in the chromium plate.

Tongues cut in plated tubing that had not been heated bent slightly outward, indicating residual tensile stresses in the plated layer. Baking the plated tubes at temperatures around 400° F. increased the tensile stresses further, as shown by greater bending of the tongue away from the tube surface. This result has been clarified by experiments showing that electrodeposited chromium subjected to a heating and cooling cycle increases in density and thereby contracts. The steel tends to restrain the shrinkage of the chromium layer and thereby increases the tensile stresses in it.

If the chromium plated steel is heated to a

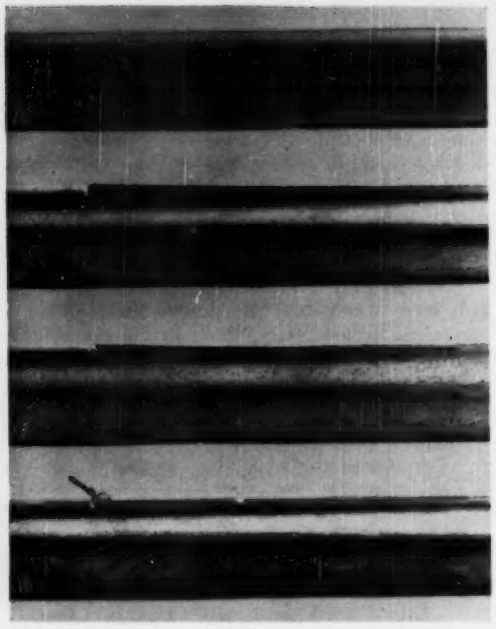


Fig. 2 — (A) Top View of Tube Showing Tongue. (B) Tube plated, heated at 390° F., and tongue subsequently cut. (C) Tube plated, tongue cut, and tube subsequently heated at 390° F. (D) Tube plated, heated at 825° F. and tongue cut; a 3/16-in. ball bearing (indicated by arrow) is resting on the depressed surface of the tongue

temperature above 750° F., the contractive forces in the chromium produce tensile stresses great enough to cause plastic flow or rupture of the plate and to relieve the residual stresses in it. Thus, when tongued tubes were heated above 750° F., the free ends of the tongues were depressed *below* the surface of the tubes, indicating a release of the restraint in the steel initially caused by residual tensile stresses in the chromium. This suggests that the increased fatigue limits produced in the fatigue specimens heated above 750° F. were caused by the relief of stresses in the chromium plate accompanying its plastic flow or rupture.

These results are presented in greater detail in my paper "Effect of Chromium Plating on the Endurance Limit of Steels Used in Aircraft", *Journal of Research*, National Bureau of Standards, Vol. 43, Aug. 1949, p. 101.

HUGH L. LOGAN
Metallurgist
National Bureau of Standards

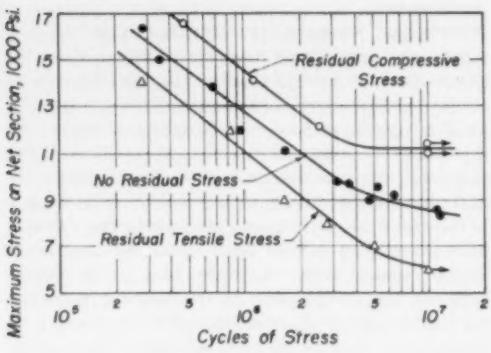
Residual Stress and Fatigue Strength

LOS ANGELES

The articles by A. L. Boegehold in the February and March issues and by E. W. P. Smith in the April issue of *Metal Progress* emphasize the importance of residual stress in the fatigue behavior of heat treated steel parts. They also point to the need for more quantitative data so that a better prediction of the actual performance can be made. Two major difficulties exist when such a prediction is attempted.

1. Along with the residual stress other changes, structural or physico-chemical, are generally induced in the heat treated parts.
2. Under service conditions a redistribution of the residual stress is possible due to the applied load.

At the University of California at Los Angeles, tests have been conducted in which the above two



factors have been controlled and the stresses measured locally by means of the X-ray diffraction technique. Notched specimens (stress concentration of 2.5) made from 3/8-in. 61S-T6 aluminum plate have been tested. Both residual compressive and tensile stresses were induced at the notch by means of a small amount of overstressing which was believed to be insufficient to produce any marked cold working. The stresses induced were 14,000 psi. as measured by the X-ray diffraction method, and their magnitude was not significantly altered during cycling.

It may be seen from the accompanying fatigue curves that an improvement of almost 100% in permissible stress and a fatigue life increased by 10 times can be realized by changing the residual stress from tension to compression.

D. ROSENTHAL AND GEORGE SINES
Department of Engineering
University of California

Health Hazards in Metal Degreasing

THE REMOVAL of grease from metal surfaces is one of the most important operations of metal cleaning. The following three methods are most often used for degreasing or for the combined operation of degreasing and removal of other surface contaminants: *(a)* alkaline cleaning, *(b)* acid cleaning and *(c)* solvent cleaning.

The potential health hazards of degreasing are probably more diversified and spread through a wider segment of the population than is generally appreciated. The process of degreasing is used in the home, offices, garages, and small and large industries. This discussion, however, is limited to the potential hazards to health associated with metal degreasing in industry.

Alkaline Cleaning

Alkaline cleaning is particularly applicable for those processes in which chemically clean metal surfaces are desired, as, for example, electroplating. The choice of alkali and strength of solution depends on the kind of metal to be cleaned and the contaminants to be removed. The general tendency seems to be to use stronger solutions where greater cleaning action is desired. Alkalis that may be used are sodium hydroxide, sodium carbonate, sodium silicate, borax, sodium perborate, trisodium phosphate and other alkali phosphates, mixtures of the preceding, and others.

Exposures potentially hazardous to health encountered in connection with the alkaline cleaning operations are caused by: *(a)* dampness, which is not only the result of vaporization of the liquid as its temperature rises toward the boiling point, but also the drainage of excess liquid onto the floor near the tank as cleaned articles are removed, *(b)* alkaline vapors which may rise from the surface of the heated cleaning solution to enter the breathing zone of personnel, *(c)* splashing of the cleaning liquid with possible skin contact, and *(d)* careless handling of the dry powders or concentrated liquid. With the exception of the last named exposure, the ones mentioned are found most frequently where cleaning is carried out in open tanks or by the use of steam guns. In enclosed cleaning systems, as found in washing machines, considerable control of exposures is inherent in the design of the machine.

Exposure to constant dampness may cause a disturbance of the skin and circulation, causing contraction of blood vessels with blanching of the skin and a decreased blood supply to the parts exposed. A continuous exposure resulting from walking on wet floors may result in a condition similar to "trench foot".

Prolonged exposure to strong alkaline solutions and mists also causes dermatitis and irritation of the respiratory tract. Continuous exposure of the skin to alkaline solutions or mists not only causes a direct irritation but also a loss of the normal acid mantle on the skin. This opens the way for bacterial invasion resulting in boils, carbuncles and various and variable skin infections.

Perhaps the most serious problem of degreasing and cleaning with a hot solution of alkali, or mixture of alkalis, requiring immediate first aid and medical attention, results from accidental burns of the eyes and skin due to the corrosive

By Paul W. McDaniel
Senior Industrial Hygienist
Pennsylvania Dept. of Health
Harrisburg

action of the caustic. Caustic burns of the eyes which may cause destructive loss of vision require immediate first aid by copious flushing with water for at least ten minutes. Facilities for flushing the eyes should be provided nearby. The patient should *not* be rushed to a physician before first aid treatment.

Minor skin burns with splashed alkaline solution or powder should be washed with copious amounts of water. An emergency shower should be provided nearby. With extensive burns of the body, treatment for shock and other life-saving measures should precede special care of eyes. The patient should be placed under a shower, then covered and kept warm. The feet should be elevated and someone should summon a physician.

Where alkalis are used for cleaning purposes, and to prevent the untoward effects described above, personnel exposures to dampness and to the various substances used should be eliminated or controlled. The use of adequate ventilation for the reduction of relative humidity and the removal of hazardous vapors is recommended. Personal protective clothing such as goggles, rubber gloves, boots, and aprons for protection against eye and skin contact with the liquid will protect the worker from accidental burns and reduce the dermatitis hazard. Respirators as needed for protection against inhalation of powders should be used.

The ventilation of alkaline cleaning tanks may be accomplished by any one of several ways. Actually, total enclosure with exhaust ventilation will give the most positive control of vapors. However, such a system is not always possible, and a partial enclosure hood or a lateral slot hood must be used. The latter type of installation generally provides least interference with the operation of the tank. Sufficient mechanical exhaust ventilation should always be provided to give positive control of vapors, and for tanks with one lateral slot hood the air removed should be at least 120 cu.ft. per min. per sq.ft. of liquid surface.

Acid Cleaning

Acid cleaning as applied to removal of greasy deposits from metal surfaces is not so widely practiced as alkaline or solvent cleaning. In instances noted during a recent investigation of metal degreasing in the northwestern section of Pennsylvania it involved the use of only one acid, phosphoric. The other common acids, such as sulphuric and hydrochloric, were used for scale and rust removal or for purposes not involving the elimination of grease.

The phosphoric acid solutions supplied for cleaning purposes are of variable composition. In addition to acid, they may contain a wetting agent, an organic solvent, or other constituents. Where acid degreasing-cleaning methods have been noted, the operation has been performed in open tanks. Exposures noted were those due to high temperature and humidity, splashing of the cleaning liquid, and air-borne vapors.

Exposure to dampness has been discussed under alkaline cleaning. Exposures to high temperature and high humidity which may be encountered in the vicinity of the hot tanks, particularly during warm weather, may cause profuse sweating, leading to a serious reduction in the normal sodium chloride level in the body. The depletion of salt may give rise to heat cramps or exhaustion among personnel.

When high temperatures are encountered, personnel exposed should be furnished salt in solution or tablet form, to replenish that lost in sweating. Where tablets are used, personnel should be advised to drink enough water to prevent nausea that might be caused by a concentration of salt in the stomach.

The problem of corrosive burns of the eyes and skin by acid is similar to that discussed under alkaline degreasing. When such burns occur, the affected parts should be promptly flushed with large amounts of water. Safety showers and facilities for flushing the eyes should be available nearby. Additional treatment should be the responsibility of the physician.

The air-borne vapors above a phosphoric acid tank may cause nose and throat irritation due to the presence of acid and may give rise to other symptoms from toxic concentrations of the solvent.

As recommended for control of exposures in alkaline cleaning, adequate ventilation should be used in acid cleaning to reduce exposures to high temperatures, high humidity and vapors. Personnel engaged in the cleaning operation should wear protective clothing and goggles as protection against the splashing liquid, and should be well instructed in methods of handling.

Solvent Degreasing

Under solvent degreasing are included two classes of solvents: *(a)* the petroleum solvents (naphtha, gasoline and others) and *(b)* the chlorinated hydrocarbons (trichloroethylene, perchloroethylene, carbon tetrachloride and others). All these solvents are poisonous to some extent. Their toxic effects depend on their vapor pressure, solubility, chemical activity and concentration. As a rule they show an affinity for the fats and lipoids in the body and chiefly affect those in the

(Continued on page 102)

Relief of excessive fabrication stresses is especially important in large welded structures. T. McLean Jasper outlines four possible methods (three in extensive use) and Wm. C. Stewart presents some data on magnitude of stresses remaining after definite heat treatments.

Stress Relief

IT HAS LONG BEEN KNOWN that commercial metal shapes or parts made therefrom retain their form in spite of a complicated set of balanced internal stresses. A simple proof of their existence is the dimensional change during heat treatment. To explain warpage, it was suspected that some of these stresses, locked up in the cold, rigid metal, were strong enough to cause permanent deformation in the hot, more plastic metal. It followed that heating a metal part would lower the *maximum* intensity of any pre-existing internal stresses. Hence, stress relief.

By and large the problem of internal stresses did not assume serious proportions until large "seamless" structures were made by fusion welding. While unwanted internal stresses can lower the endurance limit of individual parts, these failures were not so spectacular, even disastrous, as a broken penstock, a collapsed bridge, a cracked ship, or an exploded gas sphere. Such major troubles followed, here and there, the substitution of rigid welded designs for less rigid riveted structures, sometimes even without redesigning for the new joining method. A riveted seam allowed enough movement to relieve most of the erection stresses and even some of the stress concentrations induced during working or fabrication; not so the rigid weld. Suspicion extended to the weld itself; it was known, for example, that certain thin sheets could be welded with a sound joint, but that heavy plates of the same composition would likely have microcracks, due presumably to localized, overpowering internal stresses at the weld.

It is not strange, therefore, that the welding fraternity has been foremost in studying this phenomenon of high stresses not due to the calculated working loads and in devising methods for correcting or alleviating it. The following extracts from a letter written by T. McLean Jasper of A. O. Smith Corp., Milwaukee, to Prof. W. Soete of the Belgian Institute of Welding summarize the work done in this respect in America since the early 1920's.

"The welding of thick plates by the ductile type of arc welding in which high shrinkage stresses could prevail started about 1924. The need for stress relief came at about the same time. First used was stress relief by peening each layer of the weld as it was deposited. Stress relief by heat was applied in 1927. Before this, however, the effect of repeated stress in relieving internal stresses was demonstrated during the fatigue of metals investigation at the University of Illinois. Stress relief by overstressing has also been practiced for many years in America.

"I will now summarize these four methods:

"Stress Relief by Peening — This method has been used for about 25 years by the A. O. Smith Corp. and is applied in many ways, for it allows jobs to be finished which could not be completed otherwise. It also reduces distortion (stress relief by heat cannot accomplish this to the same degree). It can also reduce internal stresses of a very low intensity — far below any affected by heating below the critical point, because low temperature reduces only those internal stresses that are above the long-time yield point of the steel at the stress-relieving temperature. For these reasons the general use of peening to reduce stresses below the fracture point during welding operations is employed extensively by us. It eliminates need for successive heat treatments when welding a very thick section, say of 18 in., and it coddles tender and high-strength steels so they can be arc welded without mishap.

"Peening for stress relieving is very carefully outlined in the American Petroleum Institute's Code of 1943, Appendix G.

"Stress Relief by Heat — This, as mentioned above, has been applied since 1927 to ductile arc welding and many other types of welding as well, and is used in a production plant principally as an over-all corrective for a finished product. I would refer to the 'Science of Petroleum', Vol. 3, p. 2302, for the details of tests made prior to 1927, and which dominated the selection of the stress-relieving temperatures contained in the pressure vessel codes. Data in this book indicate very clearly that it is possible to stress relieve *below* the 1100 to 1200° F. range generally used in American shops, and which appears in all pressure vessel codes in America.

"The new Section VIII of the American Society of Mechanical Engineers' boiler code has the following table for the heat stress relief of pressure vessels:

Metal Temperature	Holding Time Per Inch of Thickness
1100	1 hour
1050	2
1000	3
950	5
900	10

"The reason why temperatures much above 1100° F. are not considered is because a pressure vessel, if large, gets out of round and in so doing builds up working stresses much faster than the heat stress relief takes them out. If a vessel is long and small in diameter it takes on the shape of a sausage. A vessel only slightly out of line builds up stresses much too fast during its operation. Some might say: 'Support and prop the vessel so as to use higher temperatures.' Well, try it out and see! We generally reheat to a temperature between 1100 and 1200° F.; the pressure vessel then keeps its shape and the welding stresses built up during construction are leveled off to a reasonable value. (In stress relieving large, bulky, solid forgings, the above does not apply and higher temperatures are practical.)

"Stress relief at lower temperature is applied most often in the field, on operating plant, in which the operating temperature itself can serve as the stress-relieving medium. It is often applied when repairs or new connections on a thick pressure vessel are necessary. During such heating the vessel is operated at a subnormal pressure, and this aids the low temperature in relieving stresses. Peening the field joints as they are made often serves the same purpose.

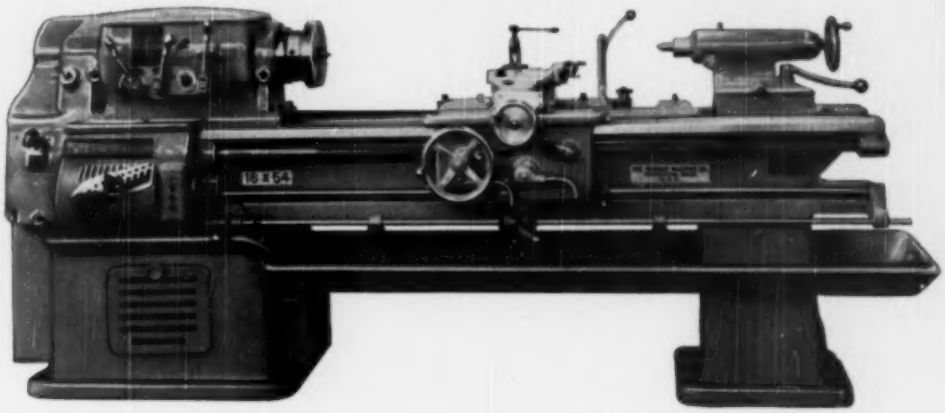
"Stress Relief by Repeated Stressing — The author, when serving (1920 to 1926) as engineer of tests for the National Research Council's research on fatigue of metals at the University of Illinois, used the relaxing method of measurement to find out how low a repeated stress value could be applied to reduce the quenching stresses in fatigue specimens. He found that if he used a specimen before any repeated stresses have been applied, very appreciable internal stresses were sometimes measured. After repeated stressing at about half the endurance limit (say two million cycles), the measured internal stresses had been reduced to less than 10% of the original high value in steels that had been quenched and then tempered at a low heat. On quenched steels tempered at a high heat the reduction due to repeated stress was small since the initial stresses were small. A diagram on p. 61 of Bulletin No. 136 of the Engineering Experiment Station of the University of Illinois shows tests of this sort on 0.50% plain carbon steel. Test pieces were the cylindrical shoulders of heat treated fatigue specimens which had been subjected to 500,000 to 10,000,000 reversals of stress whose maximum intensity was from 20 to 50% of the endurance limit. Three specimens for each drawing temperature, both prestressed and unstressed, were measured before and after relaxation, and it is seen from the following figures that repeated stressing considerably below the endurance limit has reduced residual stresses (as measured by 'units of shortening') by a very considerable amount wherever they were relatively large.

Tempering Temperature	Ultimate Tensile Test	Units of Shortening Fatigued	Units of Shortening Not Fatigued
None	127,000 psi.	+5.0	−35.0
600° F.	127,000	+2.0	−24.5
800	121,000	−1.5	−12.5
1000	107,500	−3.0	− 7.3
1200	93,000	−2.0	− 5.0
1400	86,000	−1.0	− 3.0

"Stress Relief by Overstressing — This method, more applicable to thin welds, has been applied for many years by many operators. It can be used for ductile welds and ductile steel. (Overstressing is also frequently used to stress relieve objects that are not welded.) All that is necessary is to bring the applied stresses above the yield stress of the material. Sometimes it is not necessary to load even that much. In a structure where internal stresses are high it is only necessary to apply such a load as will bring the total to the neighborhood of the yield, and the high internal stresses will relieve themselves without much distortion.

"We make pipe for the transportation of gas and oil. This pipe is made with a periphery about 2% less than that desired for the final size, and it is expanded by hydraulic pressure to the desired diameter in a circular die.

(Continued on p. 112)



NICKEL ALLOYED CAST IRONS can be specified to assure a dense, uniform structure of high hardness for wear-resistance, and with well dispersed graphitic areas for good anti-frictional properties as well as ready machinability.

How NICKEL CAST IRONS help machine tool users

Hold down Production Costs

SCORING and WEAR in machine tools cause dimensional changes that make accuracy and output fall sharply. *Then, unit production costs rise...*

Solve this problem by using nickel cast iron for induction-hardened and flame-hardened parts of your products or equipment.

Records show that nickel cast iron parts make it possible for tools to retain their initial accuracy much longer than would similar castings of plain iron. The Hendey 16" x 54" Toolroom Lathe, shown above, is but one of scores of examples.

The Hendey Machine Company, Torrington, Connecticut, found the induction method best for lathe bed ways that must retain accuracy. Their engineers specify a 1¼ per cent nickel alloy cast iron, induction-hardened to provide a minimum reading of 70 on the Shore scleroscope (about 500 BHN). Distortion never exceeds 0.012" in a 6-foot length of this nickel cast iron, and the depth of the hardened skin runs as high as 3/32".

Nickel in cast iron lowers the critical transformation range, thus promoting greater depth of hardness than in plain iron, and minimizing distortion. Moreover, there is gradual blending of the hardened layer into the softer pearlitic interior, whereas in unalloyed iron the transition zone is apt to be completely graphitized and hence extremely weak.

Consult us on the use of nickel alloyed irons to meet your casting requirements. Send us details of your problems today.

EMBLEM OF INCO SERVICE

Over the years, International Nickel has accumulated a fund of useful information on the properties, treatment, fabrication and performance of engineering alloy steels, stainless steels, cast irons, brasses, bronzes, nickel silver, cupro-nickel and other alloys containing Nickel. This information is yours for the asking. Write for "List A" of available publications.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

Exposures for Cobalt-60 Radiography of Steel*

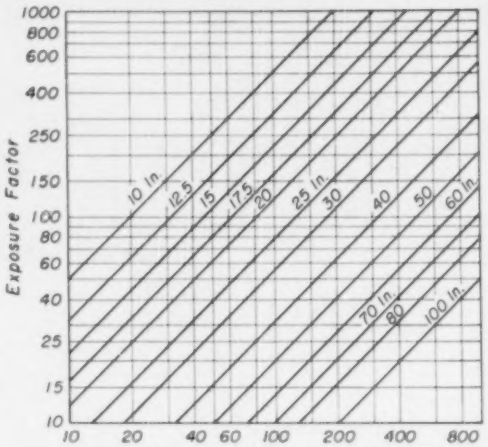
By A. Morrison, National Research Council of Canada, Ottawa, Ontario

COBALT-60 is a gamma-ray source less costly than radium and is available in units of greater activity so that shorter exposure times are possible. In the accompanying exposure charts:

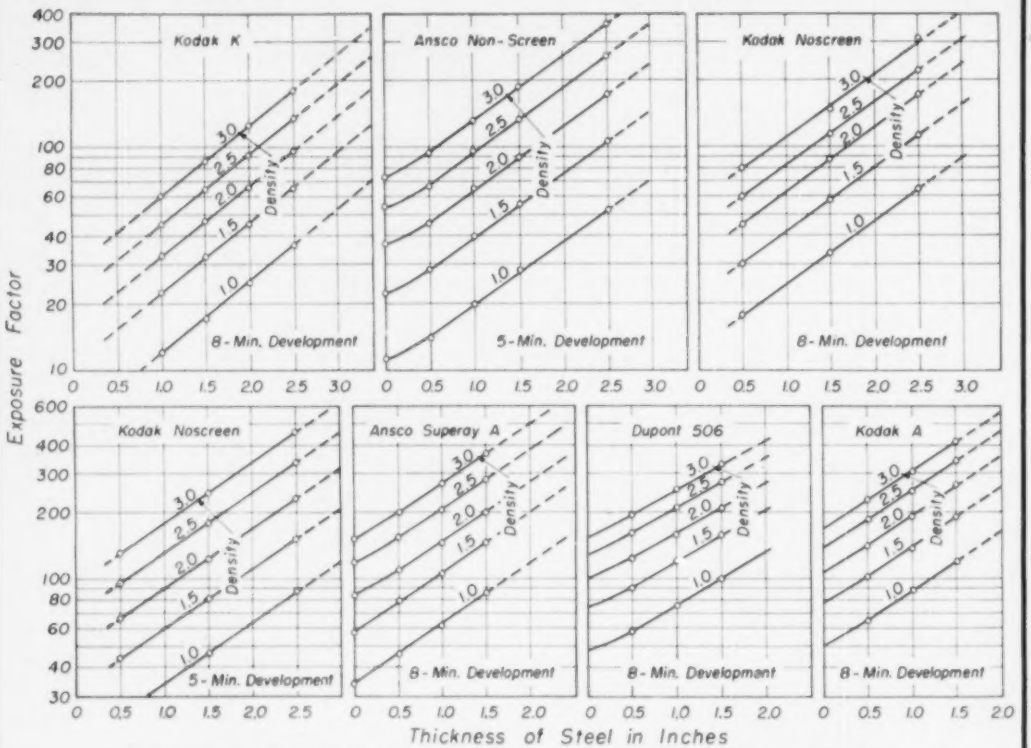
$$\text{Exposure factor} = \frac{S \times t}{d^2}$$

where S = milligram radium equivalent of source
t = time of exposure in minutes
d = distance from source to film in inches

The milligram radium equivalent was determined by comparing each cobalt source with a radium source of about 250 mg. radium content, by means of an ionization chamber. At present, sources having gamma radiation equivalent to that from 2.4 g. of radium consist of a cylinder of cobalt 6.5 mm. in diameter by 6.5 mm. high. However, results from "equivalent" sources are not identical because of differences in the gamma-ray spectra of radium and cobalt. As the half-life of cobalt-60 is only 5.3 yr., its source strength must be corrected at intervals of about six months.

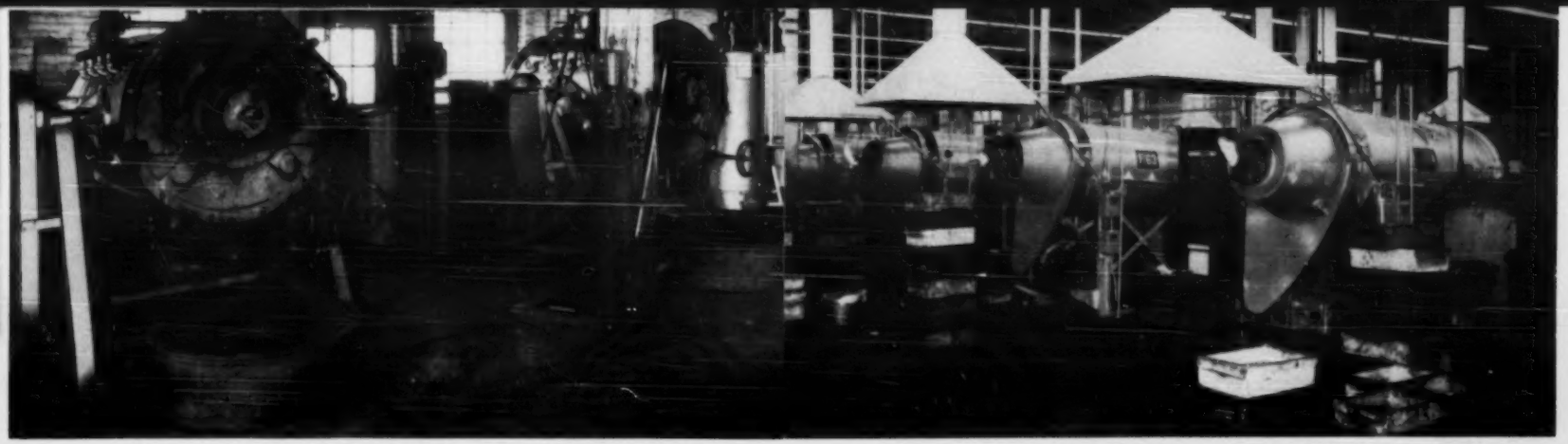


For 100 mg. multiply by 5.00
200 mg. multiply by 2.50
250 mg. multiply by 2.00
300 mg. multiply by 1.67
400 mg. multiply by 1.25
1000 mg. multiply by 0.50



CONDITIONS FOR ABOVE GRAPHS: Screens — 0.015-in. lead, front and back. Development — Kodak Rapid X-Ray developer, 68° F., standard agitation, duration as indicated on each graph.

*Charts are from "Radiography With Cobalt-60", by A. Morrison, *Nucleonics*, December 1949, p. 19 to 32 (copyright, 1949, by the McGraw-Hill Publishing Co.; reprinted by permission). The original article includes discussion of sensitivity in cobalt radiography and a comparison of radium and cobalt-60 as sources.



A battery of A.G.F. Batch-Type Rotary Carburizing Furnaces at the plant of Pioneer Steel Ball, Inc., Unionville, Connecticut, consistently produces uniform case depths with controlled carbon penetration to provide desired hardness and toughness of ball products.

A group of A.G.F. Continuous Rotary Furnaces at the plant of the American Screw Company, Willimantic, Connecticut, process screws and miscellaneous parts uniformly, maintaining specified case depths and desired physical properties of the cores.

ROTARY FURNACES — *Batch or Continuous*

The overall economies of operation afforded by A.G.F. Rotary Furnaces produce a substantially lower cost per unit of work heat treated than is possible with any other type of furnace.

WORK HANDLING IS MINIMIZED. A.G.F. Continuous Rotary Furnaces have adjustable, self-metering feed hoppers which permit preloading of work. If desired, continuous feeding mechanisms may be employed to completely eliminate the need for an operator.

A.G.F. Batch-Type Rotary Furnaces are easily charged and discharged by means of a tilting mechanism, which is power driven on the larger models.

UNIFORMITY OF PRODUCT is assured by

1. Retort rotation thoroughly mixing the work.
2. Positive control and maintenance of atmosphere in the retort.

LONG ALLOY LIFE is realized because the retort remains in the heat at all times.

VERSATILITY. Rotary Furnaces are used in the metal working industry without modification for various types of general and atmosphere work, such as clean hardening, carburizing, case hardening, normalizing, and Ni-Carbing. In the process industries, these same furnaces are used for calcining carbonates and nitrates, burning garnet grain and other similar processes.

VARIOUS SIZES are available to suit your particular requirements.

For your production heat treating, investigate A.G.F. Rotary Furnaces.

WRITE US TODAY

AMERICAN GAS FURNACE CO., ELIZABETH 4, N. J.

A COMPACT PHOTOMICROGRAPHIC DEPARTMENT...*In One Unit!*

This unit, properly supplemented, will handle all types of photomicrography. Every component has been designed to give you new adaptability, speed, ease and efficiency in:

1. **Visual Microscopy**
2. **High Power Photomicrography, with Transparent and Opaque Specimens**
3. **Low Power Photomicrography, with Transparent and Opaque Specimens**
4. **Photocopying**

WRITE for your copy of detailed, informative Catalog No. E-210, to Bausch & Lomb Optical Co., 638-S St. Paul St., Rochester 2, N. Y.

Bausch & Lomb *Model L* Photomicrographic Equipment

Although the modulus of elasticity of a metal is rather insensitive to most metallurgical variables, alloying elements may have significant effects. Magnitudes of these and other effects are indicated in the following review article.

The Modulus of Elasticity—

A Review of Metallurgical Factors

THE MODULUS OF ELASTICITY (Young's modulus, E) has always been of greater mechanical than metallurgical interest because of its importance in design and its insensitivity to virtually all metallurgical factors. The designer's interest in this property does not extend much beyond a simple desire for accurate numerical values to substitute in his formulas. Physical metallurgists, on the other hand, have accumulated a considerable body of data relating the modulus to changes in temperature, composition and structure of alloys.

Since David J. Mack's critical review of the data and theory on Young's modulus in 1946 (A.I.M.E. *Transactions*, Vol. 166, p. 68), the *Zeitschrift für Metallkunde* has published four comprehensive papers by Werner Köster on metallurgical aspects of the modulus (Vol. 39, 1948, p. 1-9, 9-12, 111-120, 145-158). These recent data indicate the possibility of increasing the modulus of some metals by appropriate metallurgical control. The present contribution may be considered as supplementing Mack's review, with particular emphasis on the German work published in 1948.

The Effect of Temperature—For comparison of the temperature variation of E in both high and low melting alloys, the data may be plotted as a function of the ratio of the absolute temperature to the absolute melting temperature (Fig. 1). Most of these data reveal that the modulus decreases almost linearly with increasing temperature. It is interesting to note that the modulus for the closely packed face-centered cubic structure of gamma iron is greater than that for the less dense body-centered cubic structure of alpha iron. Undoubtedly the lower modulus of alpha iron is primarily attributable to the greater distance between the atoms in this structure. The modulus is also sensitive to the magnetic state of the elements, and over the range of the Curie temperature where alpha iron changes from ferromagnetic to paramagnetic its modulus of elasticity decreases.

The effect of atomic structure on the modulus, as revealed by plotting E at atmospheric temperature as a function of the atomic number, is shown in Fig. 2. It must be recognized that this method of comparison has several minor defects: It neglects considerations of interatomic distances and magnetic states, both of which affect the modulus. Furthermore, the comparisons should be made at equivalent temperatures—perhaps at the Debye characteristic temperature for each element—rather than at a fixed temperature. Such refinements, however, would not alter the general trends and comparisons. Several interesting con-

By John E. Dorn
Professor of Physical Metallurgy
and Thomas E. Tietz
Research Engineer
University of California, Berkeley

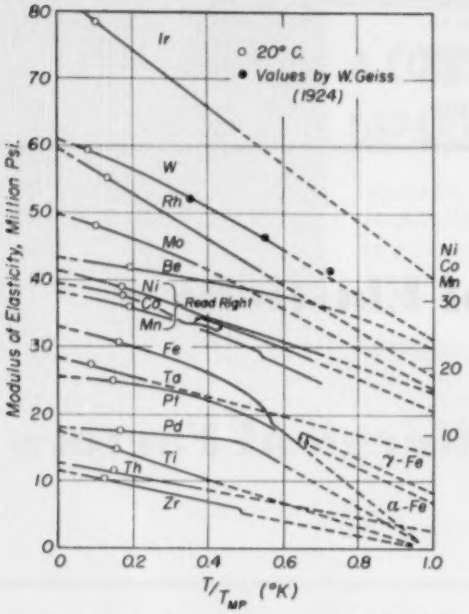


Fig. 1 — Effect of Temperature on the Modulus of Elasticity of Fifteen Metals (Köster)

clusions are directly deducible from the data presented in Fig. 2.

1. For the first two short periods of the periodic table (as, for example, the second period consisting of Na, Mg, Al, Si) the modulus increases with increasing atomic number. Undoubtedly two factors contribute to this trend, namely, the increase in the number of binding electrons and a decrease in the atomic radii with increasing atomic number.

2. Proceeding vertically down any column of the periodic table (as, for example, Be, Mg, Ca, Sr, Ba), excluding the transition series of elements, the modulus decreases with increasing atomic number. As the valences of the elements in a single column of the table are identical, this trend is probably due primarily to the increasing atomic radius of the elements with increasing atomic number in the column.

3. The transition elements (for example, the first transition series, Sc, Ti, V, Cr, Mn, Fe, Co, Ni) have exceptionally high moduli of elasticity. Inasmuch as the increase in E is attributable to higher binding forces between the atoms of the solid element, it necessarily follows that the d-electrons of the transition series contribute appreciably to the binding energy of the solid. The fundamental mechanism whereby the d-electrons contribute to the binding is at present largely speculative.

4. The maximum modulus for the second and third transition series occurs at the elements ruthenium and osmium, each having about six d-electrons. In the first transition series iron also has six d-electrons and it would, therefore, be suspected that it also should exhibit the greatest modulus in its series. Actually, the modulus of iron is almost the same as that for cobalt, the element next higher in the periodic sequence. But the modulus for cobalt refers to the closely packed face-centered cubic lattice, whereas that for iron refers to the more loosely packed body-centered cubic structure. If, then, the comparison of moduli were based on the same structure, iron would exhibit the maximum modulus among the

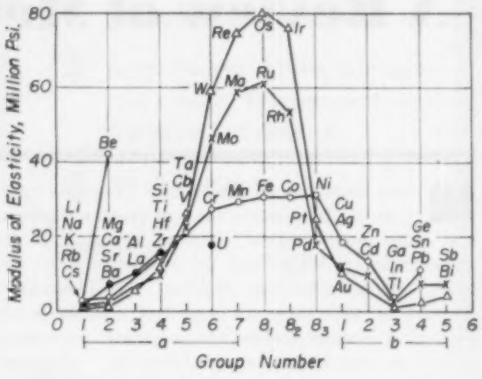


Fig. 2 — Periodic Variation of the Modulus (Köster)

elements of its period. Consequently, the highest modulus and, therefore, the highest binding forces among the elements in a transition series invariably is obtained at the element that has six d-electrons.

5. When the transition elements having the same number of d-electrons are compared (as, for example, Fe, Ru, Os) the modulus increases appreciably with increasing atomic number. This trend is contrary to that of the nontransition elements and it is also contrary to expectations based solely on the atomic radii. For as the atomic number increases in this sequence the radius also increases and the modulus would normally be expected to decrease. Obviously, the increase in the strong binding of the transition elements having the same number of d-electrons with increasing atomic number arises from some yet undetermined factor, which has such a pronounced effect that it far outweighs the smaller effect of decreasing binding with increasing atomic radius. If this factor could

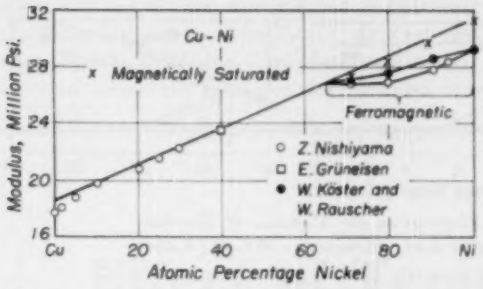


Fig. 3 — Modulus of Copper-Nickel Alloys (Köster)

be uncovered substantial strides might be made in improving the moduli of alloys.

6. Although plastic properties are highly structure-sensitive, whereas the elastic properties are structure-insensitive, there is nevertheless a relationship between the modulus and other mechanical properties. For example, when the hardness of the pure metals is plotted in periodic fashion, analogous to the data in Fig. 2 for the modulus of elasticity, a similar periodic trend is obtained. This fact establishes the rather strong dependence of the flow stress for plastic deformation of metals on their binding energies.

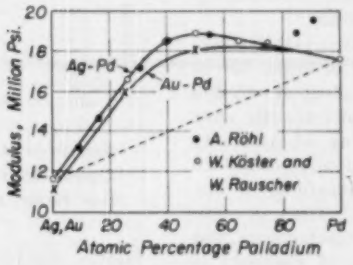


Fig. 4 — Ag-Pd and Au-Pd Alloys

Effects of Alloying — In view of the uncertainty concerning the fundamental origin of the moduli of the elements, particularly the transition elements, it is not surprising that even less is known about the effect of addition elements on the moduli of binary alloys. It is a prevalent concept that, in general, the modulus is rather insensitive to alloying elements. This thesis is frequently correct, but Köster's recent evidence has shown that in many systems rather substantial changes in the modulus are obtainable by alloying.

The simplest type of binary alloy is one in which the two elements are mutually soluble over the entire range of compositions. This occurs only when the two elements have the same crystal structure, almost identical atomic radii and similar valences. Under these conditions the binding energy would not be much different from that of each of the elements and it would be anticipated that the modulus might vary linearly with the atomic percentage of the solute. This is usually true, as shown by the data for copper-nickel alloys given in Fig. 3. In other completely miscible binary alloys, for example, silver-palladium or gold-palladium, the simple linear relationship does not hold, as shown in Fig. 4, and a maximum modulus is obtained in the alloys having 50 atomic % palladium. Whether such systems of binary alloys exhibit an increase or a decrease in modulus with alloying additions, however, appears to depend on the test temperature as shown for the silver-gold series given in Fig. 5. Here additions of the second element increase the modulus at low temperatures, whereas they decrease it at higher temperatures.

In general the modulus of elasticity of terminal solid solutions decreases rather rapidly with increasing atomic percentage of the solute element for alloy systems that form intermetallic compounds. Typical examples of this effect are shown in Fig. 6 and 7 for a number of magnesium and aluminum alloys. In general those elements having the lowest solubility in atomic per cent also exhibit the greatest decrease in the modulus of elasticity. Zener has suggested (*Acta Crystallographica*, Vol. 2, 1949, p. 163) that this effect is primarily attributable to the change in interatomic spacing which causes the attraction to be less than that in the pure metal when the atoms are displaced from the positions of lowest energy which obtain in the pure solvent metal. On the other hand, additional factors probably enter the analysis because in a few alloy systems that form intermetallic compounds the modulus increases with increasing concentration of the solute element, as shown in Fig. 8.

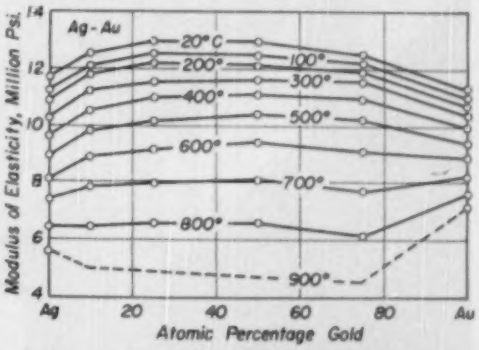


Fig. 5 — Modulus of Silver-Gold Alloys (Köster)

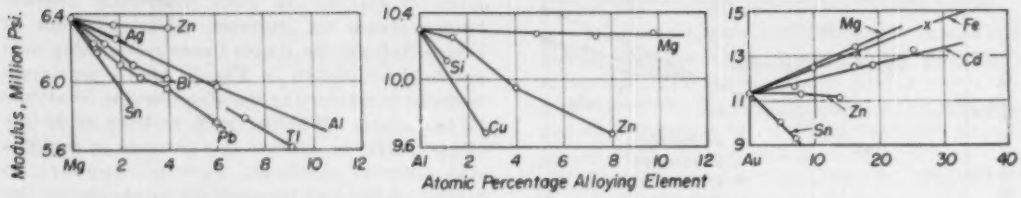


Fig. 6, 7 and 8 — Effect of Various Alloying Elements on the Modulus of Elasticity of the Terminal Solid Solutions Based on Magnesium, Aluminum and Gold (Köster)

The modulus of intermetallic compounds may be either higher or lower than that of the elements in the compound. A typical example of the modulus variation with structure is shown in Fig. 9 for the aluminum-copper system. Here the modulus of $CuAl_2$ is greater than that for aluminum but less than that for copper. In general, the higher the melting temperature of the intermediate phase, the higher is the binding energy and consequently the higher is the modulus of elasticity.

Since the modulus of elasticity is rather structure-insensitive, it is independent of grain size in a single-phase region and independent of the dispersion in a two-phase region. Consequently, over a two-phase region the modulus of elasticity changes almost linearly with the atomic percentage of the added element from the modulus of one phase to that of the second phase. Thus, in addition to physical factors such as temperature and magnetic condition, the modulus of elasticity is also sensitive to such metallurgical factors as crystal structure, cold work and alloying. Some beneficial adjustments of the modulus can be achieved by appropriate variation of these metallurgical factors. But before full advantage of this approach can be achieved much additional work will be required to uncover the fundamental factors relating to the binding of the elements in metallic structures.

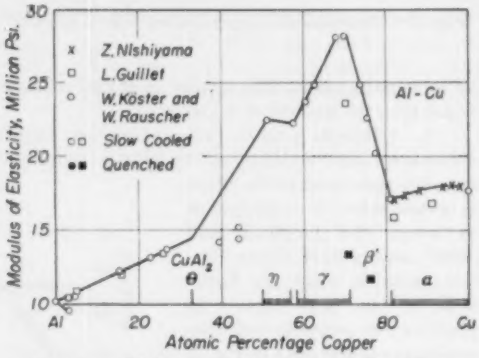
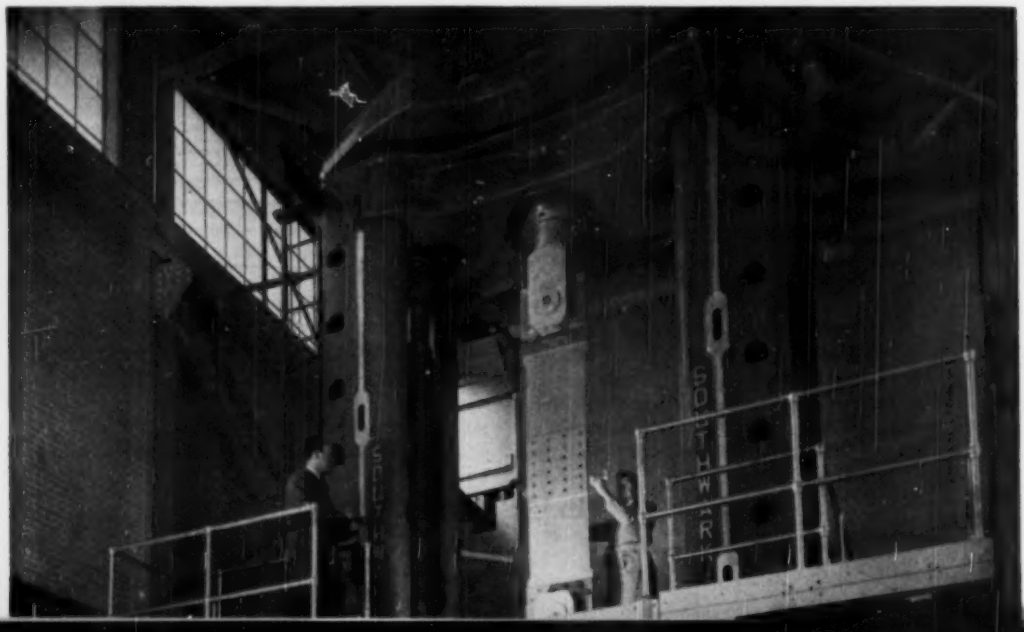


Fig. 9 — Modulus of Elasticity of Aluminum-Copper Alloys Throughout the Entire Concentration Range, as Measured at Room Temperature

Courtesy Aluminum Co. of America



This article presents new data on temperature variation of Young's modulus for the following metals: Stellite 21, Inconel, four austenitic stainless steels, Armco iron, S.A.E. 4130 and 75S aluminum alloy. A dynamic method of testing was used in which the specimen was vibrated transversely at its resonant frequency.

Effect of Temperature on the Modulus of Elasticity*

THE MODULUS OF ELASTICITY is becoming an increasingly important criterion for the selection of alloys for mechanical and structural applications. For certain aircraft components and engine parts, a choice of alloy may depend on a difference of 0.1 or 0.2 million psi. in the modulus. It therefore becomes important to obtain accurate modulus values for many metals and alloys.

Information concerning Young's modulus may be based on either static or dynamic measurements. The dynamic method described in this paper can be used for research or for acceptance testing and evaluation of materials for critical applications. It would be far less costly and time consuming than obtaining equivalent data by conventional tensile, compression or bend tests. However, static tests may be necessary where the state of stress is a variable under consideration.

Measuring the Dynamic Modulus — In the dynamic method, a slender right cylinder or prism of the test material is suspended horizontally and caused to vibrate transversely (in the vertical plane). Its fundamental natural frequency is then determined through location of the proper resonance peak of vibration. From this frequency, and the mass and dimensions of the test bar, the modulus of elasticity is calculated by means of a simple equation. The apparatus is readily arranged to measure moduli at temperatures above and below ambient, and may be adapted for vacuum and inert atmosphere conditions.

David J. Mack[1] has given a fairly complete review of the knowledge of Young's modulus up to 1945, including both static and dynamic methods of measurement.

W. Köster and F. Förster[2] and their co-workers in Germany have used the same apparatus and specimen to measure both Young's modulus and damping. M. Roberts and J. Nortcliffe[3] in England employed a simplified version of this test equipment. The apparatus used to obtain the data presented in this article (Fig. 1) was very similar to that used by Roberts and Nortcliffe.

An interesting low-frequency variation of the transverse-vibration dynamic method, developed about 1933 by P. LeRolland and P. Sorin in France,[4] has been widely used. It is described by Mack.[1] In more recent work, however, L. Guillet and co-workers in France have used Cabarat's

*Most of the work reported in this article was done at Battelle Memorial Institute in 1949, and the results were submitted to the Ohio State University as part of the requirements for the degree Master of Science in Metallurgy.

[1]References are on p. 100.

By Charles W. Andrews
Project Engineer
Brush Beryllium Co.
Cleveland

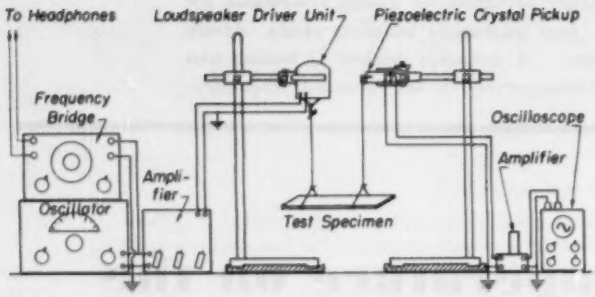


Fig. 1 — Apparatus Used in Determining the Dynamic Modulus

apparatus, which utilizes high-frequency longitudinal vibrations to measure both modulus and damping.

The cylindrical specimen used in the present work was of the same dimensions as that used by Roberts and Nortcliffe[3] and Jones and Nortcliffe.[5] It measured 6 in. long by $\frac{3}{16}$ in. in diameter, and was used whenever bar stock was the test material. It was found to be optimum in size and proportions as regards ease of excitation, sharpness of resonance in vibration, and loading of the detecting element. A shorter, thicker specimen would be much easier to machine, but would be difficult to vibrate at detectable amplitude.

Sheet materials were of greatest interest during this series of tests, so a test specimen of suitable dimensions had to be developed. For the thicknesses encountered (0.020 to 0.060 in.), a specimen 3 in. long by ½ in. wide was found satisfactory. The resonant frequency of a longer specimen was too low to be measured accurately with the equipment available, unless its width were increased so much as to make it awkward to use. The 3 x ½-in. specimen was lighter than optimum, so far as excitation of the crystal pickup was concerned, but it seemed to be the best compromise.

Operation of the test setup shown in Fig. 1 was as follows: The signal from a good audio oscillator, low in harmonics, was fed into an amplifier and thence into the driver unit (transducer). The corresponding mechanical output of this was fed through one of the specimen support strings into the specimen, which vibrated with detectable amplitude only if the oscillator frequency was close to the natural frequency of the specimen. Such near-resonance vibrations were transferred through the other support string from the specimen to the crystal pickup, and the corresponding alternating current signal generated by the pickup was amplified and fed into a small cathode-ray oscilloscope. A 500-μμfd. condenser was connected in series with the pickup to minimize disturbance of the oscilloscope pattern by miscellaneous low-frequency mechanical vibrations. An accurate frequency bridge was connected as shown in Fig. 1 to measure the frequency of the signal from the oscillator. Support strings were attached to the specimen just inside the nodes of the fundamental mode of vibration (Fig. 2).

The driver unit used here consisted of an obsolete electrodynamic loudspeaker with the cone and outer frame removed. A light metal frame carrying a small hook was cemented to the voice coil form. The voice coil was held in reasonable alignment, even after removal of the speaker cone, by its centering spider. The pickup used was an ordinary piezo-electric crystal phonograph pickup, with an output rating of about 1 volt. The suspension strings were attached directly to the needle of the crystal pickup and to the hook on the driver unit, respectively. The asbestos support strings were replaced after each run at high temperatures, since they became crumbly after exposure to temperatures above about 1000° F.

The electric-resistance tube furnace used for tests at high temperatures is shown in Fig. 2. Three holes were provided through the top, properly spaced for support strings carrying either the

Table I — Description of Test Materials

No.	Alloy	Composition	Form	Condition
1	Stellite 21	62 Co, 27 Cr, 6 Mo, 2 Ni, 0.25 C	Sheet, 0.035 in.	Annealed, 2200° F.
2	Inconel	80 Ni, 15 Cr, 5 Fe	Sheet, 0.026 in.	Annealed, 1950° F.
3	18-8 (Type 304)	19 Cr, 9 Ni, 0.07 C, 2.0 max. Mn	Sheet, 0.037 in.	Annealed
4, 5	18-8 (Type 347)	19 Cr, 10 Ni, 0.07 C, 1.0 Cb	Sheet, 0.040 in.	Cold rolled, ½ hard
6	18-8 (Type 303)	18 Cr, 9 Ni, 0.12 C, 0.1 Se	Bar stock	Cold drawn, ½ hard
7	25-20 (Type 310)	25 Cr, 20 Ni, 0.20 C, 2.0 max. Mn	Sheet, 0.020 in.	Annealed, 2050° F.
8	Armco Iron	0.012 C, 0.017 Mn, trace Si	Sheet, 0.030 in.	(Not available)
9, 10	4130 Steel	0.31 C, 1.0 Cr, 0.21 Mo, 0.44 Mn	Bar stock	Norm., ann.
11	75S Aluminum	5.5 Zn, 2.5 Mg, 1.5 Cu, 0.3 Cr, 0.2 Mn	Sheet, 0.032 in.	T6 (aged)
12	75S Aluminum	5.5 Zn, 2.5 Mg, 1.5 Cu, 0.3 Cr, 0.2 Mn	Bar stock	T6 (aged)

cylindrical 6-in. or the rectangular 3-in. specimen. A thick stainless steel tube surrounded the specimen inside the furnace, to improve the temperature distribution along the specimen. The ends of the furnace were plugged, and two thermocouples were placed as shown in Fig. 2 to register temperature as near as possible to the specimen.

The frequency response of the apparatus was best between about 400 and 2000 cycles per sec.; consequently the specimen sizes were selected to fall in this range. While the furnace could be used at temperatures up to 2000° F., it was very difficult to vibrate most metal specimens at temperatures higher than about 1500 to 1800° F. with sufficient amplitude to permit locating the resonant frequency. (Tests of aluminum were, of course, limited to considerably lower temperatures.) High damping capacities of the test metals at these temperatures almost annihilated resonance phenomena.

[The procedure in making a high-temperature run, the equations used for calculating the dynamic modulus, and a statement about the accuracy of the results are given on p. 96.]

Table II — Hardness of Test Materials

Alloy	Maximum Test Temperature	Rockwell Hardness		
		Before Test	Superficial (15-T)	
			Before	After
Stellite 21 (s)	1800° F.	B-106	95	95
Inconel (s)	1800	B- 72	84	83
Type 304 (s)	1800	B- 78	87	85
Type 347 (s)	1900	B-109	96	85
Type 303 (b)	1800	—	—	—
Type 310 (s)	1800	B- 73	84	84
Armco Iron (s)	1600	B- 38	78	74
4130 (b)	1500	—	—	—
75S (s)	750	E-106	92	66
75S (b)	700	—	—	—

(s) Sheet stock. (b) Bar stock.

Experimental Results

Table I lists the ten materials tested in this program and gives the approximate composition, form (sheet or bar stock) and condition of each. Table II gives Rockwell hardnesses of the materials before and after test, and the approximate maximum temperatures to which each was exposed during test.

Figures 3 to 7 show the variation in modulus with temperature for the ten materials tested, both during heating and cooling. Similarities among the slopes of certain of the curves are summarized in Table III by giving an approximate mean temperature coefficient of the modulus and the range over which it applies, for each of several groups of curves. The two ferritic materials, Armco iron sheet and 4130 steel bar stock, show no significant linear portion in their modulus-temperature curves. Since the slopes of the two curves are similar, however, they have been put in the same group and a range has been given for the temperature coefficient of the modulus.

It may be noted in Fig. 6 and 7 that Köster's[8] curves for "pure iron" and "pure aluminum" agree quite well in slope and curvature with the author's curves for Armco iron and 75S aluminum alloy, respectively. Also, if the temperatures of the discontinuities in the three curves in Fig. 6 are compared with the transformation temperatures for the corresponding compositions, the agreement is surprisingly good. Insufficient data were obtained to show transformation discontinuities on cooling for the Armco iron and 4130 steel.

For several of the materials, cooling curves of the modulus are considerably higher than the heating curves, and the room temperature modulus is higher after heating (in test) than before. The longitudinal specimen of stabilized 18-8, the Stellite 21 and the 25-20 alloy are outstanding in this respect. As cold work is likely to change the modulus of a metal, the effect of heating on cold rolled 18-8 is not surprising. The difference in response between longitudinal and transverse specimens may also be explained. The changes in modulus with cold work and subsequent annealing (as during test) are believed to result from a combination of at least three factors — changes in elastic anisotropy due to rotation of grains toward certain preferred orientations, introduction and release of residual stresses, and introduction and release of elastic strain energy. This has been shown, for instance, by McAdam and Mebs,[10] who reported a 36% decrease in the static tensile modulus of an 18-8 stainless steel — from 32.2 to 20.7

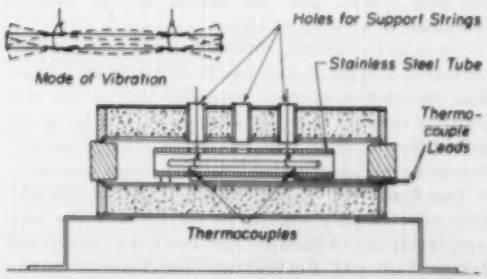


Fig. 2 — Furnace and Mode of Specimen Vibration

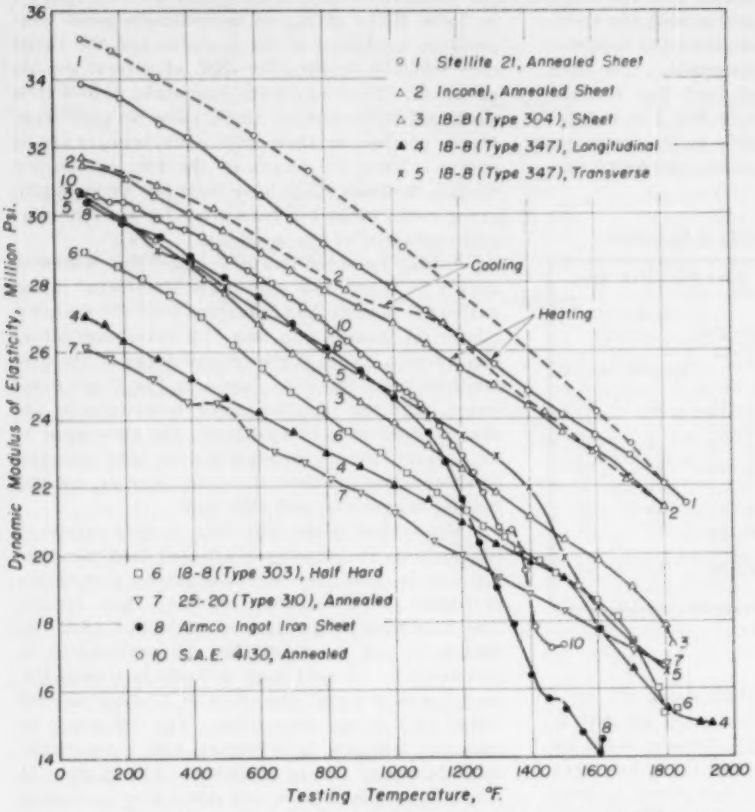

Dynamic Modulus of Elasticity, Million Psi.
Testing Temperature, °F.
1 Stellite 21, Annealed Sheet
2 Inconel, Annealed Sheet
3 18-8 (Type 304), Sheet
4 18-8 (Type 347), Longitudinal
5 18-8 (Type 347), Transverse
6 18-8 (Type 303), Half Hard
7 25-20 (Type 310), Annealed
8 Armco Ingot Iron Sheet
10 S.A.E. 4130, Annealed
Cooling
Heating

Fig. 3 — Effect of Temperature on the Modulus of Elasticity of Eight Materials

million psi. — due to tensile plastic deformation of 58%. Annealing would be expected to increase this modulus to nearly its original value. The relative magnitudes of the three factors listed above, and consequently the direction and intensity of any effect of cold work on the modulus, will depend on the material, the stress system causing the cold work, and the extent of the plastic deformation by cold working.

It is not clear why the final room temperature moduli of Stellite 21 and the 25-20 alloy are higher than the initial values. Principal causes for the increase may be relief of stresses caused by prior quenching or other heat treatment, and precipitation or aging phenomena resulting from exposure to the high test temperatures. Other materials were affected only slightly by exposure to the test temperatures. Although the cooling curve of Armco iron did not retrace the heating curve (Fig. 6), the difference is probably due to a heavy layer of oxide resulting from exposure to the high test temperatures. That is, the apparent modulus was low because of the weight of the oxide and reduction of the metal cross section, but the true modulus was unaffected. Removal of this layer by hand polishing increased the modulus after test almost to the initial room temperature value. Remachining probably would have erased the remaining difference.

The bumps upward in the modulus-temperature curves for the 25-20 Cr-Ni alloy (Fig. 5) remain unexplained. However, their appearance during both heating and cooling seems more than coincidence.

It should be noted in Fig. 7 that the static modulus of 75S alloy decreased much more rapidly with increasing temperature above about 400° F. than did the dynamic modulus. This difference might be accounted for in large part by the creep and relaxation that is believed to take place in some aluminum alloys at temperatures above 400° F. in static tests. Probably this does not occur to any great extent in dynamic tests.

Table III — Temperature Coefficients of Modulus

Alloy	No.	Range	Temp. Coeff.
Stellite 21 Annealed 18-8 Cold Drawn 18-8 (Se)	1 3 6	to 1600° F.	7000 psi./°F.
Inconel 18-8 (Cb) (longitud.) 25-20 Cr-Ni	2 4 7	to 1400	4500
18-8 (Cb) (trans.)	5	to 1200	6300
75S Aluminum	11, 12	to 700	3700
Armco Iron S.A.E. 4130	8 10	to 1000	5000 to 8000

Summary

It is believed that the data presented here give a reasonably accurate picture of the effect of temperature on the elastic modulus, and that the data would be especially applicable to design for vibrational loads.

The mean temperature coefficient of the dynamic modulus for each of the materials except aluminum is between about 4500 and 8000 psi. per °F., up to about 1000° F. The temperature coefficient for the 75S aluminum is about 3700 psi. per °F. up to about 700° F. Deviations above these limiting temperatures are due to softening of most of these materials and in general correlate with greatly increased damping capacity and decreased resistance to creep and relaxation.

Suggestions for Future Work

In a permanent setup, the whole apparatus should be built on a heavy frame. The supports for driver and detector (pickup) units may be mounted to slide on separate rubber-mounted rails or tracks, for adjustment to the length of specimen or position in the furnace. It would be desirable to have the furnace built in two halves, with the suspension string holes replaced by a single long slot. The halves could then be mounted to slide axially along a track mounted rigidly in the main frame of the apparatus. Then the test specimen could be cooled rapidly by sliding the two halves of the furnace apart without disturbing the specimen or its suspension. Also, any difficulties with the specimen suspension or thermocouples occurring during the run might be rectified using the same procedure, without the need for completely cooling the furnace.

It is suggested that for making determinations in vacuum or protective atmosphere, the whole apparatus should be made smaller and more sensitive, and that a smaller specimen should be used. Then a fairly vacuum-tight chamber could be built around it, and measurements could be made readily in either vacuum or a protective atmosphere almost as easily as in air.

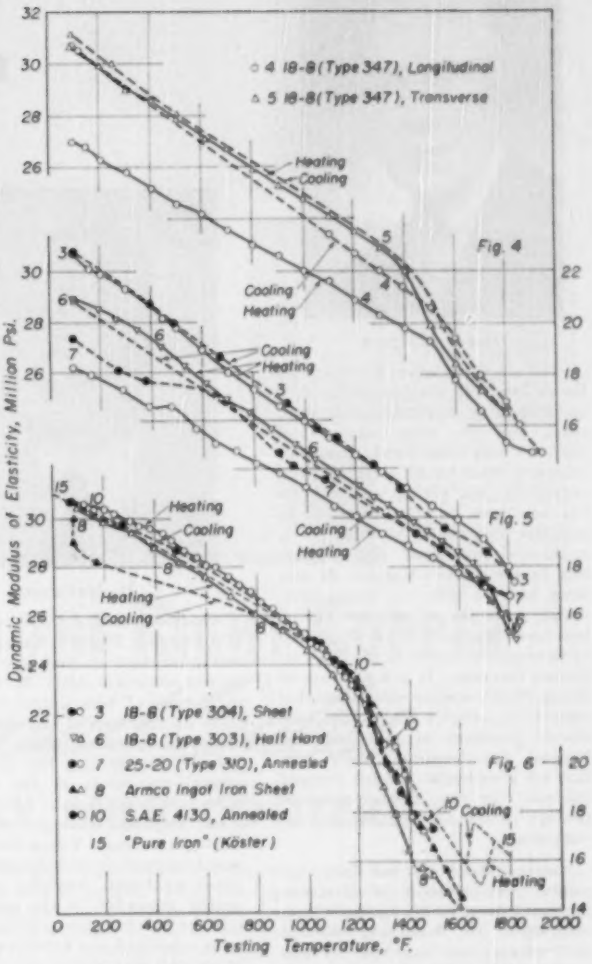


Fig. 4, 5 and 6 — Dynamic Modulus of Elasticity Versus Temperature for Seven Ferrous Materials

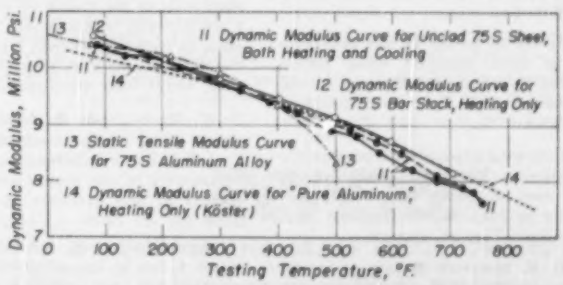

Dynamic Modulus, Million Psi.
Testing Temperature, °F.
11 Dynamic Modulus Curve for Unclad 75S Sheet, Both Heating and Cooling
12 Dynamic Modulus Curve for 75S Bar Stock, Heating Only
13 Static Tensile Modulus Curve for 75S Aluminum Alloy
14 Dynamic Modulus Curve for "Pure Aluminum", Heating Only (Köster)

Fig. 7 — Modulus Versus Temperature for Aluminum and 75S

Personal Mention

Henry M. Heyn

Surface Combustion furnaces and **Henry Heyn** ⊖ are practically synonymous to most metallurgical engineers, for the sales manager of Surface's heat treat division has been selling to them for 25 years. In fact, practically his entire working life has been there, since he started in the post-war depression of 1921 as a mechanical draftsman. His membership in the Detroit Chapter ⊖ also dates back to 1925. In these intervening years the art and practice of heat treating have been revolutionized by atmosphere control in efficient continuous furnaces. It is a measure of Henry Heyn's stature within a highly competitive industry that he has been elected president of the Industrial Furnace Manufacturers' Assoc., and that his presidential address stressed the need for even further progress through continuous research and development.

George Sachs ⊖ has been appointed vice-president of Horizons, Inc., of Princeton, N. J., and Cleveland, Ohio. Dr. Sachs was educated in Germany, but has been in this country since 1936. He was at Case Institute of Technology for nine years as director of the Metals Research Laboratory and since 1949 has been president of Metals Research Assoc., Cleveland.

James B. Kenny ⊖ has been promoted from assistant chief metallurgist to chief metallurgist of the Buchanan, Mich., plant of the Clark Equipment Co.

Following graduation from Queen's University, **Henry C. Armstrong** ⊖ has been employed as a sales engineer by Johnson, Matthey and Mallory, Ltd., Toronto, Ontario.

B. B. Beckwith ⊖ is now in the sales division of the Commonwealth Industries, commercial heat treaters of Detroit.

C. H. Mathewson

Students, admirers and associates of **Champion Herbert Mathewson** ⊖ met in his honor on June 23 on the eve of his retirement after 43 years on the faculty of Yale University, 31 of them as chairman of the department of metallurgy in Sheffield Scientific School. His teaching life thus spans several transitions in the art and science of metallurgy. At the very outset emphasis was upon ore dressing and smelting. Young Mathewson was interested in metallography and phase systems. Applying this advanced viewpoint to the copper alloys, he and his many eminent graduates examined and improved the existing mill practices in the neighboring Connecticut industries. Delving more deeply into the mechanism of plastic flow, he came up with a fundamental concept that was directly applicable to the rolling of pure zinc, a traditionally brittle metal. A grand man, an inspiring teacher, a renowned metallurgist, his multitude of friends wish him a long and satisfying life.

W. Mack Crook ⊖, formerly assistant chief engineer of the Hunt Tool Co., has established a consulting service in the design and development of new products and equipment for oil fields.

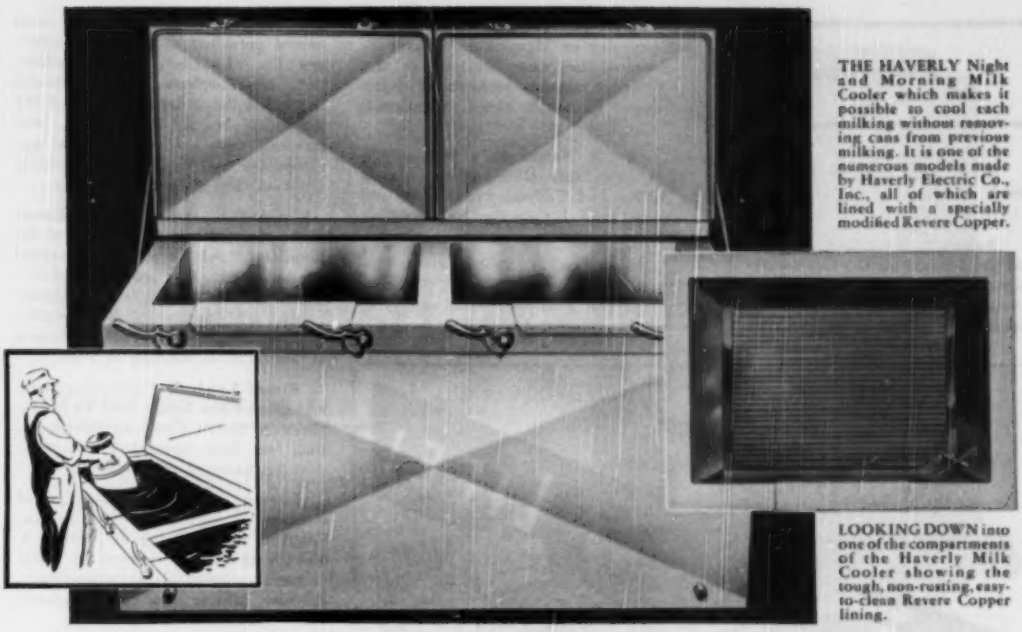
Donald Rogers ⊖, formerly a research fellow at Rensselaer Polytechnic Institute, has taken a position with the Sprague Electric Co., North Adams, Mass., as a research engineer.

Kent R. Van Horn

At the outset of a gracefully written piece about the 1945 president of the American Society for Metals, the biographer makes this somewhat prophetic statement: "In addition to being learned in metals, Van Horn is a Man of Parts, as his superiors in the Aluminum Company—who thought at first they had merely hired a research metallurgist—have come to find out." In his working life of 21 years with Alcoa, **Kent R. Van Horn** ⊖ has been research metallurgist, specializing in radiography, assistant manager of the Cleveland research division, manager of the division (succeeding the late Louis W. Kempf), and then assistant director of research in forgings and castings for the entire company. Effective August 1, he will become associate director of research for Alcoa and transfer to the central headquarters in New Kensington, Pa., succeeding Herman E. Bakken who becomes vice-president and general manager of the Aluminum Ore Co.

Arthur W. Peterson ⊖, formerly in the metallurgy department of Massachusetts Institute of Technology, is now chief metallurgist at the Parker Pen Co., Janesville, Wis.

Following graduation from Rensselaer Polytechnic Institute, **Ronald E. Turner** ⊖ has become associated with Queen City Sand & Supply Co., Buffalo, N. Y., where he succeeds his father as sales manager.



THE HAVERLY Night and Morning Milk Cooler which makes it possible to cool each milking without removing cans from previous milking. It is one of the numerous models made by Haverly Electric Co., Inc., all of which are lined with a specially modified Revere Copper.

LOOKING DOWN into one of the compartments of the Haverly Milk Cooler showing the tough, non-rusting, easy-to-clean Revere Copper lining.

HOW COPPER, THE RIGHT COPPER *Increased Sales* OF HAVERLY MILK COOLERS

On farms throughout the country mechanical refrigeration for the cooling of milk has been growing by leaps and bounds. Late in 1945, there were many complaints from the farmers regarding the war-quality rustable material used to line these milk coolers. They were difficult to clean and were rusting out rapidly.

When restrictions were lifted on copper and copper alloys, the Haverly Electric Co., Inc., Syracuse, N. Y., came to Revere to see if non-rusting, easy-to-clean copper could be used. The solution was not as easy as it sounds. For the copper, in addition to its non-rusting and high thermal conductivity properties, also had to be strong enough to withstand the constant banging of 80-lb. cans of milk, and at the same time sufficiently ductile for easy fabrication.

Two Revere sheet metal specialists and their staffs went to work. Tests showed electrolytic copper was not mechanically feasible. Then tests were run with several modified oppers. One of these was found to possess *all* of the requirements.

This use of copper as a liner for milk coolers further resulted in the development of the Haverly "Floating Ice" feature. The ice forms on the side walls of the smooth copper liner; works loose and floats to the surface, adding cracked ice cooling around the top of the can at the cream line, where fast and efficient cooling is needed and proves most profitable. Hence a more efficient unit. Also, due to copper having the highest heat-conductivity of any other commercial metal, copper cooling coils are attached to the outside of the copper lining. This results in greater cooling efficiency and easier cleaning. Here again Revere helped. The Revere welding department developed a fast method of attaching this Revere Dryseal Copper Tube to the lining.

The final outcome is that sales of the Haverly Electric Co., Inc., have increased until they are selling all they can produce of this type cooler, while the mutual knowledge gained has resulted in this company expanding its use of special copper alloys in coolers for other industries.

Perhaps Revere can be of help in developing or improving your product, increasing your sales. Why not call the Revere Sales Office nearest you next time you have a problem in metals?

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y.
Sales Offices in Principal Cities, Distributors Everywhere

Personals

H. E. North, Jr., is now president of Arcadia Metal Products, Arcadia, Calif.

Robert E. Ward is now manager of the foundry at the Eclipse-Pioneer division, Teterboro, N. Y., of Bendix Aviation Corp. He was previously director of metallurgy of the division.

Following graduation from the University of Wisconsin, **William E. Beyer** has been working in the rates and methods department of the General Malleable Corp., Waukesha, Wis.

Paul E. Nelson, a March 1950 graduate from Michigan College of Mining and Technology, is now employed by J. I. Case Co., Racine, Wis., in their training program.

A. L. West, Jr., has been transferred by Aluminum Co. of America to the San Francisco office where he is an architectural specialist.

EFFICIENT HANDLING with TRAYS and BOXES *engineered* by STANDARD ALLOY

Material handling equipment to meet the heating characteristics of the furnace . . . to achieve longer life . . . results from Standard Alloy's experienced engineering.

Trays, boxes and belts are designed simply, sturdily to solve the specific handling problem involved. Scores of designs from the engineering files of Standard Alloy are available for any application.

For any operation concerning alloy castings — trays, containers, fixtures, conveyors, roller hearths, etc. — consult Standard Alloy. Write for the helpful 24-page catalog.

STANDARD ALLOY CO., INC. 1679 COLLAMER ROAD CLEVELAND 10, OHIO

BUFFALO
E. A. Mansfield
Elliott Square

CINCINNATI
Pearson Browne
1st National Bank Bldg.

PHILADELPHIA
Towle & Son
18 W. Chelton Ave. Bldg.

MINNEAPOLIS
R. E. Hayden
7445 First Ave. So.

PITTSBURGH
Robert A. Schmidt
404 Frick Bldg.

CLEVELAND
C. B. Jackson Sales & Engr. Co.
15201 St. Clair Ave.

CHICAGO
Harry N. Steffes
4821 W. Cortland St.

LONGMEADOW, MASS.
R. G. Constantine
Control Engineering Co.
31 Converse St.

HOUSTON
B. F. Combs
2321 Telephone Rd.

DETROIT
Gehringer & Forsyth
16151 James Couzens Highway

MILWAUKEE
Ed. P. Lindergren
3748 W. Greenfield Ave.

NEW YORK CITY
R. B. Steele
254 West 31st St.

Donald H. Thorburn has been named president of the Gas Machinery Co. (Canada), Ltd, Hamilton, Ont. Mr. Thorburn, on the executive council of the Ontario Chapter of the American Society for Metals, was formerly associated with several gas companies as well as the Public Utilities Commission of Ontario.

Donald E. Babcock, engineer at the Youngstown, Ohio, plant of the Republic Steel Corp., was awarded the American Iron and Steel Institute Medal for his paper on "Sulphur Control and Manganese Conservation in Open Hearth Furnaces", presented at the Institute meeting in 1949.

Rudolf Lowit, formerly general manager of the Elmet Div., Lewiston, Maine, of North American Philips Co., Inc., has been appointed vice-president in charge of this division.

Having accepted a position of mechanical engineer with American Smelting and Refining Co., **Orest A. Meykar** is now engaged in mechanization project at their subsidiary, Buchans Mining Co., Ltd., Buchans, Newfoundland, Canada.

Joseph R. Lane is now head of the high-temperature metallurgy branch of the metallurgy division of the Naval Research Laboratory, Washington, D. C.

Frank J. Bubsey is now metallurgist and process engineer at the American Blower Corp., Columbus, Ohio.

David J. Greer, formerly with Appalachian Smelting & Refining Co., has accepted a position with the Tin Processing Corp., Texas City, Tex., as assistant chief chemist of the metallurgical laboratories.

D. K. Miner, who has been a trainee at the General Electric Co. since his graduation from Michigan State College, has been assigned the position of engineer in the materials and process group of the aircraft gas turbine division in West Lynn, Mass.

Ernest G. Kendall, formerly an instructor in metallurgical engineering at the Polytechnic Institute of Brooklyn, is now with the development department of the Titanium Div., National Lead Co., South Amboy, N. J.

After completion of the loop course of Bethlehem Steel Co. at Bethlehem and Johnstown, Pa., **Ralph Duffett, Jr.,** has worked in the metallurgical department and has recently been promoted to stripper foreman in the openhearth department of the Johnstown plant.

A SAFEGUARD FOR COMBUSTION

that speaks its mind!

SPECIFY FLAME-OTROL—for safe and efficient operation of all types of oil and gas fired burners for furnaces, ovens, boilers, kilns and other heating equipment. It speaks its mind through colored light signals to keep you constantly informed of all phases of its service—from automatic self-proving safe start to safe shut-off at the slightest indication of improper operation. For combustion safety—specify the new Wheelco 1300 FLAME-OTROL, a compact *completely engineered package* providing more safety, economy and uninterrupted operation than any other combustion safeguard on the market.

The combustion safeguard systems designed by Wheelco comply with all the standard practices recommended by leading underwriters and insurance groups.

get all these benefits in one compact unit!

Instantaneous protection—	Electronic circuit
plus Waiting period not subject to human error—	Automatic tube warm-up
plus Shut down or repeat of "lighting-off" cycle at operator's discretion—	Reset button
plus Automatic check of all internal components to insure safe "lighting-off"—	Safe-start component check
plus Selective and adjustable timing programs for Ignition cycles, purging and pre-ventilation—	Easily performed with 7 interchangeable plug-in units
plus Constant visual indication of burner system operation—	Built-in signalling system
plus Completely engineered package for economy of cost and installation—	Built-in push-button start eliminating external installation

Flame-eye

Flame-rod

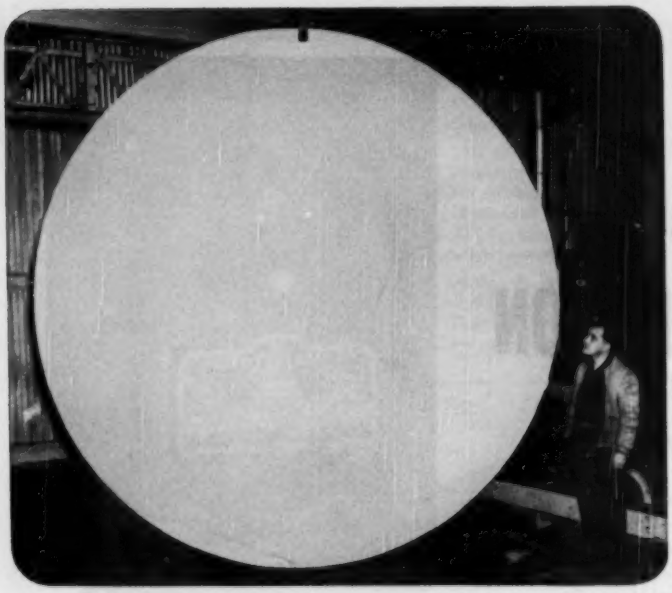
All operations protected against all hazards created by sticking relays.

Write for Bulletin F2-2, Wheelco Instruments Company, 825 W. Harrison Street, Chicago 7, Illinois

instrumentality

Get Wheelco instrumentality in combustion safeguards, recording, indicating and controlling instruments.

wheelco electronic controls



Are you going around in
STAINLESS CIRCLES?

Cutting Stainless Steel to shape is easy—when you have the proper equipment.

G. O. Carlson, Inc. regularly supplies diameters from our own plate in sizes ranging from less than one inch to the world's largest —to your precise specifications, in any thickness.

You usually save money and time by ordering diameters, circles, rings, and heads from G. O. Carlson, Inc. Highly specialized cutting facilities for Stainless Steel have been developed at our plant to handle a wide range of requirements. Why not take advantage of our equipment?

Send us your next order for stainless steel diameters—produced from plate to chemical industry standards, cut to your order ready to use.

G. O. CARLSON, INC.

Stainless Steels Exclusively

300 Marshalton Road, Thorndale, Pa.

PLATES • FORGINGS • BILLETS • BARS • SHEETS (No. 1 Finish)

District Sales Offices and Warehouse Distributors in Principal Cities

Personals

George A. Barker, former secretary-treasurer and vice-chairman of the Lehigh Valley Chapter, American Society for Metals, has been transferred by Bethlehem Steel Co. from supervisor of specifications and experimental department of the metallurgical division of the Bethlehem, Pa., plant to the New York City sales office to head forging and casting sales.

Philip R. White, who received his M.S. from Columbia University in 1949, is at present a research metallurgist at the General Motors' Research Laboratories Division in Detroit.

Edward R. Bergin, formerly assistant superintendent of the machine shop at Chase Brass & Copper Co., has been appointed sales engineer in the New England district by Peterson Steels, Inc., Newark, N. J.

Formerly assistant metallurgist of Dominion Engineering Works, **H. M. Brownrigg** has been appointed assistant works manager of the Joliette Steel Div., Dominion Brake Shoe Co., Joliette, Quebec.

Lewis N. Rohrbach, formerly owner of Mineral Research Laboratory, is now employed by the Morgan Petroleum Corp., Akron, Ohio, as mineralogist and authorized representative in the sales division.

After graduation from the University of Michigan with a B.S.E., **William E. Hopkins** is now working as a trainee for American Brake Shoe Co., Mahwah, N. J.

W. G. Irwin, following graduation from the University of Toronto, has accepted a position with the engineering staff of Marathon Paper Mills of Canada, Ltd., Marathon, Ontario.

Edwin N. Hess has recently accepted a position as trainee in the inventory and production control departments at the Phoenix, Ariz., plant of Reynolds Metals Co.

A. E. Zeisel announces the formation of Frigilātem Welding Alloys, Inc., Neptune, N. J., of which he is president.

Sylvester D. Donohue, formerly sales representative with the Burden Bryant Co., is now general manager and assistant treasurer, Donohue Coal Co., Worcester, Mass.

When a TAM* field engineer calls...

You can obtain a wealth of practical, useful and authoritative information by discussing your technical problems with a TAM sales engineer. He's well equipped to work for and with you. More than ten years ago he received his degree in Metallurgical Engineering from one of our leading universities. Since then, his education has been broadened by wide experience. In the field, he has been called upon to assist in the solution of simple and complex problems. He has had his coat off and his hand-in on more than a few plant projects. His advance information on new metallurgical developments and applications is a valuable asset.

Here is a man ready to work with you. You will find him intelligent and cooperative—quick to understand your problems. Furthermore, he is your direct contact with a fully equipped and staffed headquarters that is the source of much worthwhile information and data. When your TAM engineer calls, get the full value that his background offers you.

TAM PRODUCTS

Registered U. S. Pat. Off.

*TAM is a registered trademark.

TITANIUM ALLOY MFG. DIVISION
NATIONAL LEAD COMPANY

Executive and Sales Office: 111 BROADWAY NEW YORK CITY · General Offices, Works, and Research Laboratories: NIAGARA FALLS, N. Y.

The Universally Recognized Leader in

HARDNESS TESTING

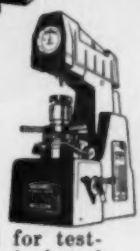
Instruments, Equipment and Accessories

There is only one measure of value in hardness testing equipment: Dependable Accuracy.

For 28 years, Wilson has made a full time job of providing equipment for research, educational and industrial hardness testing. The Wilson Standardizing Laboratory has been largely responsible for Wilson-made equipment becoming the universally accepted standard.

Choose your Wilson hardness testing instrument on the basis of your individual requirements with pre-assurance of dependable accuracy.

TUKON—for micro-indentation hardness testing with either Knoop or 136° Diamond Pyramid Indenter. Made in 3 models to cover the full range of Micro and Macro Hardness testing with loads from 1 to 50,000 grams.



"ROCKWELL" Hardness Tester

developed and made only by Wilson. For laboratory, toolroom or production line testing. Vertical capacities from 3¼" to 16". Motorized models available.

"ROCKWELL" *Superficial*

HARDNESS TESTER—especially suited for testing thin material, nitrided or lightly carburized steel and areas too small for regular "ROCKWELL" Hardness Tests. Depth of indentation .005" or less. Satisfactory for general testing where surfaces are smooth and materials homogeneous.

ACCESSORIES

"*BRALE*" is the only diamond indenter made to Wilson's precision standards. • *TEST BLOCKS*—enable you to keep your instrument "Laboratory" accurate. • *EQUITRON*—fixture provides means for accurately positioning test samples. • *ADAPTER*—permits testing inner cylindrical surfaces with unimpaired accuracy. • *WORK SUPPORTS*—facilitate testing of variously shaped rod stock, tubing or irregular shapes.

FOR DETAILED INFORMATION

—fill in the coupon below and mail to us.

WILSON MECHANICAL INSTRUMENT CO., INC.

AN ASSOCIATE COMPANY OF AMERICAN CHAIN & CABLE COMPANY, INC.

230-F PARK AVENUE, NEW YORK 17, N. Y.

ACCO

Please send me further information on the subject checked:

TUKON ☐ "ROCKWELL" Hardness Tester ☐

"ROCKWELL" Superficial ☐ Accessories ☐

NAME _____

TITLE _____

COMPANY NAME _____

ADDRESS _____

CITY _____ STATE _____

Dynamic Modulus

THE procedure in making a high-temperature test run in the apparatus described on p. 86 and 87 was as follows: A resonant frequency determination was first made with the specimen suspended outside the furnace. Oscillator and amplifier gains were advanced about ½ each; the oscilloscope gain was set at about ½. The oscillator was tuned through the expected frequency range, and when a resonance peak was noted on the oscilloscope, the oscillator was held at the corresponding frequency while the node points of the specimen were located by laying a wire on it at a number of points along its length. If the vibration was not in the first mode, the oscillator was retuned in the proper direction and the check was repeated until the first mode resonance peak was found. The corresponding frequency was then measured on the frequency bridge.

The specimen was carefully resuspended inside the furnace, still at room temperature, and the resonant frequency was rechecked. Then the power to the furnace was turned on and frequency measurements were taken simultaneously with temperature readings at temperature intervals of 100, 50 or 25° F. By making the mode check at room temperature, and following the frequency-temperature curve at sufficiently small temperature increments, the operator could be quite sure that the specimen was vibrating in the first mode at all temperatures. When the maximum temperature of the run was reached, the furnace power was shut off and the frequency was measured at a number of temperatures during the furnace cooling of the specimen. A redetermination of the room temperature resonant frequency after cooling was routine. The rate of heating for most of the determinations reported was about 10 to 15° F. per min. Specimens were furnace cooled at a much slower rate.

Equations

The fundamental equation for the transverse vibration of a "free-free" beam is given by J. P. Den Hartog[6] and other authors on mechanical vibrations. Derivation from this of a working equation for a cylindrical *(Cont. on p. 98)*

It can show you the heartbeat of a car radio—

You could cover pages with calculations about a car radio vibrator. You could fill sheets with figures on inertia and elasticity of its vibrating elements—and yet not be sure exactly how the rapidly moving parts do behave in action.

This is where high speed movies come in—the kind of "slow motion" you get from the Kodak High Speed Camera. It's a simple, direct means to record and study high speed repetitive mechanical motion . . . the only way to see dynamically what happens in non-cyclic high speed action.

The Kodak High Speed Camera can take a second of action and spread it over three minutes. It can put flash marks along the side of the film that time the motion accurately. Its optical system gives the extra picture sharpness you need to see a vital point clearly.

This camera is a single unit with one motor, complete in itself and easy to operate. If you would like to know how it works and how it can help you, send the coupon.

EASTMAN KODAK COMPANY
Industrial Photographic Division
Rochester 4, N. Y.

the Kodak *High Speed* Camera

"Kodak" is a trade-mark.

EASTMAN KODAK COMPANY
Rochester 4, N. Y.
Gentlemen:
Please send me: ☐ your folder "Magnifying Time" which tells about the Kodak High Speed Camera. ☐ a 16mm. sample reel of high speed motion study, which I may borrow.

Name _____ Firm _____

Address _____

City _____ State _____

Kodak

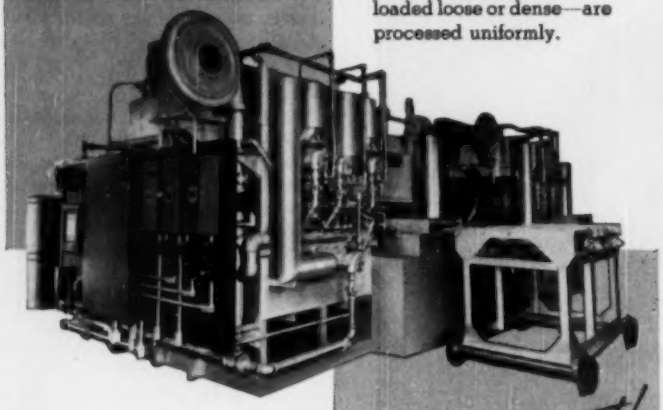
. . . BLAZING THE HEAT TREAT TRAIL

New Production-line Holcroft batch-type furnace

This compact heat-treat furnace has a vestibule, heating chamber, quenching tank—all above floor level and in one unit.

does more jobs...

You'll be able to handle a wide variety of jobs at temperatures ranging from 400° to 1700° F., and get clean, scale-free work. All contamination is removed by a high flow of generator gas in the vestibule. The furnace fan circulates atmosphere so that parts—loaded loose or dense—are processed uniformly.



faster...

The furnace can be operated automatically, or manually, by push-button controls. To save time, the temperature is built up between cycles to a point higher than necessary; then the normal operating temperature control is resumed after the cool parts enter the furnace. The quench tank handles the full load in one operation.

at a lower cost!

The furnace requires minimum floor space, no pit for the quenching tank. It can be moved easily—as a unit—to any part of the production line. Trays last longer because they are carried—*not* pushed or pulled while hot.

Want more information? Write us today!

SINCE 1916 Holcroft AND COMPANY

BUILT BY HOLCROFT & COMPANY DETROIT, MICH.

PRODUCTION HEAT TREAT FURNACES FOR EVERY PURPOSE

6545 EPWORTH BLVD. DETROIT 10, MICHIGAN

CHICAGO 9 C. H. Martin, A. A. Engelhardt 4209 South Western Blvd.

CLEVELAND 2 Wallace F. Schott 6516 Detroit St.

HOUSTON 1 R. E. McArdle 5724 Navigation Blvd.

CANADA Walker Metal Products, Ltd. Windsor, Ontario

EUROPE S. O. F. I. M. Paris 8, France

Dynamic Modulus

(Starts on p. 96) specimen, and conversion to proper units, gives an equation identical to that given by Roberts and Nortcliffe for a cylindrical specimen,[3] except for a difference of 0.2% in the constant. This difference in the constant may be accounted for by the limited number of significant figures in the constant of the fundamental equation given by Den Hartog.

The equation given by Roberts and Nortcliffe for a cylindrical specimen,[3] converted to the desired units, is:

$$E = 0.918 \cdot 10^{-8} \left(\frac{l}{d}\right)^4 \cdot \frac{w}{l\,(1 + \alpha t)} \cdot f^2 \text{ psi.} \quad (1)$$

where E = elastic (Young's) modulus in psi.
l = length of specimen in inches
d = diameter of specimen in inches
w = weight of specimen in grams
α = thermal coefficient of expansion of specimen per °F.
t = temperature of determination in °F.
f = fundamental frequency of resonant vibration of specimen in cycles per second.

For a rectangular specimen the equation is:

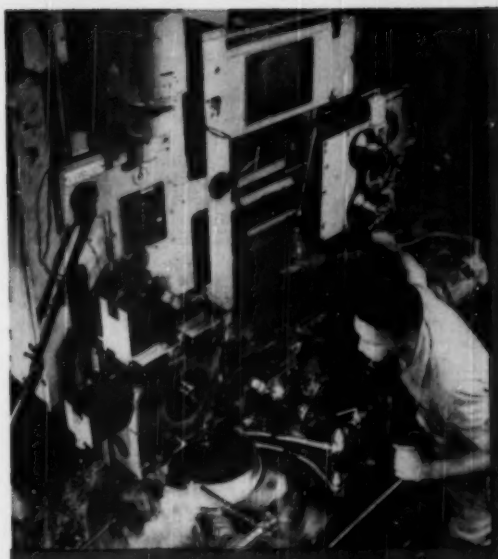
$$E = 0.541 \cdot 10^{-8} \cdot \frac{l^4}{bh^3} \cdot \frac{w}{l\,(1 + \alpha t)} \cdot f^2 \text{ psi.} \quad (2)$$

The terms are the same except:

b = width of specimen in inches
h = thickness of specimen in inches.

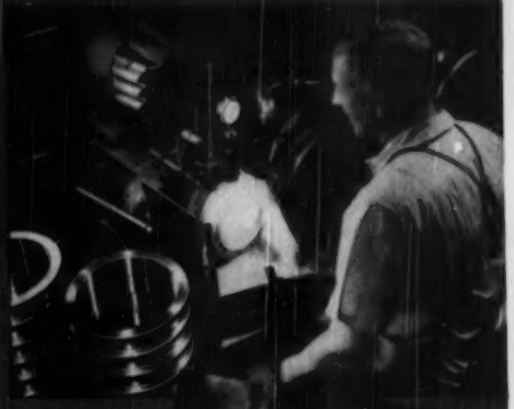
Equation (2) is derived from equation (1) by substituting for the moment of inertia of a circular cross section $\left(\frac{\pi d^4}{64}\right)$, that of a rectangular cross section $\left(\frac{bh^3}{12}\right)$. In either of these equations, the term $\frac{w}{l\,(\pi d^2/4)}$ (cylindrical specimen) or $\frac{w}{lbh}$ (rectangular specimen) may be taken out and replaced by the density, d, if an accurate figure is available for the test material.

Roberts and Nortcliffe indicated an accuracy of about 2% for elastic moduli determined dynamically, using the equation from which Equations (1) and (2) were derived. Their apparatus was similar to that described on p. 86 and 87, and they used the 6-in. long cylindrical specimens. Since the accuracy attainable with the sheet specimens was not considered to be so high as with *(Cont. on p. 100)*



"We found out the hard way...

Just how important cutting oils are"



reports a Midwest Machine Shop Superintendent.

"Sure, we knew different operations required different cutting oils. But it wasn't until we got into real trouble over rejects of one tricky part that we called in a Cities Service specialist.

That's when we learned about the complete line of oils available for specific applications. Now we don't set up a job without Cities Service expert advice on the right type of cutting fluid."

On all machining operations requiring cutting fluids, the correct tooling and the right type of cutting fluid will help give you these extra production benefits:

- ★ Longer Tool Life
- ★ Better Finish
- ★ Closer Tolerance
- ★ Greater Accuracy
- ★ Higher Speed Operation
- ★ Increased Production

A complete line of Petroleum Products for the Metal Working Industry including the following well-known brands: Chillo, Pacemaker, Q-T, Sentry, Optimus, etc.

Write for this **FREE** booklet

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

CITIES SERVICE OIL CO.
Sixty Wall Tower, Room 635
New York 5, N. Y.

Please send me, without obligation, a copy of "Metal Cutting Fluids."

Name_____

Company_____

Address_____

City_____ State_____

Dynamic Modulus

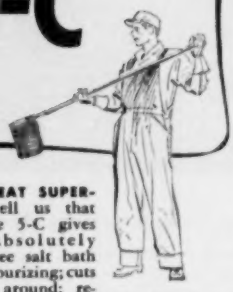
(Starts on p. 96) the cylindrical specimen, this accuracy figure doubtless was not so good for some of the data reported here. For most of the values reported, an accuracy of 3% appears reasonable. The dynamic modulus measured at frequencies of the order of 1000 cycles per sec. is essentially adiabatic, whereas the modulus measured in static tests is isothermal. Roberts and Nortcliffe reported that the difference between adiabatic and isothermal moduli was less than 0.5% for most steels, so they neglected it. Hearmon,[7] in his excellent review on elastic constants and anisotropy, has shown an equation for calculating the difference between isothermal and adiabatic moduli, and some typical values of the difference. He indicated that the difference is almost invariably smaller, often considerably smaller, than the error of measurement of the modulus, even by the most advanced methods. This difference has been neglected in the modulus values presented here, but it has been considered in the 3% accuracy figure.

Calculation has shown that for most of the tests an error of 5° F. in temperature measurement of the specimen could not have accounted for an error greater than about 0.5% in the modulus, except in one or two tests at temperatures above 1200° F. Most of the temperatures reported are considered accurate to better than ±5° F. Slower heating rates than those used here should increase the accuracy of temperature measurement.

References

1. "Young's Modulus — Its Metallurgical Aspects", by D. J. Mack, *Transactions* of the American Institute of Mining and Metallurgical Engineers, V. 166, 1946, p. 68-85.
2. "A New Instrument for Determining the Modulus of Elasticity and the Damping Capacity", by F. Förster, *Zeitschrift für Metallkunde*, V. 29, April 1937, p. 109-115.
3. "Measurement of Young's Modulus at High Temperatures", by M. Roberts and J. Nortcliffe, *Journal* of the Iron and Steel Institute, V. 157, Nov. 1947, p. 345-348.
4. "A New Method for the Determination of the Modulus of Elasticity", by P. LeRolland and P. Sorin, *Comptes Rendus*, V. 196, Feb. 1933, p. 536-538.
5. "Note on the Temperature Variation of Young's Modulus of Various Steels", by F. Jones and J. Nortcliffe, *Journal* of the Iron and Steel Institute, V. 157, Dec. 1947, p. 535-536.
6. "Mechanical Vibrations", by J. P. Den Hartog, McGraw-Hill Book Co., New York, 1943.
7. "Elastic Constants of Anisotropic Materials", by R. F. S. Hearmon, *Reviews of Modern Physics*, V. 18, July 1946, p. 409-440.
8. "The Temperature Dependence of the Elastic Modulus of Pure Metals", by W. Köster, *Zeitschrift für Metallkunde*, V. 39, Jan. 1948, p. 1-9.
9. "An Appraisal of the Usefulness of Aluminum Alloys for Supersonic Aircraft and Guided Missile Construction", by C. Craighead, L. W. Eastwood and C. H. Lorig, Technical Survey Report to Project Rand from Battelle Memorial Institute, Aug. 2, 1948, p. 38.
10. "Tensile Properties of Nickel, Copper, Open-Hearth Iron, and Typical Steels", by D. McAdam, Jr., and R. Mebs, *Journal of Research*, the National Bureau of Standards, V. 28, 1942, p. 311-378.

Heat Treat Men DEMAND
PARK-KASE 5-C
WATER SOLUBLE
LIQUID CARBURIZER



Automotive door parts. Carburized up to 40 min. in PK-5C at 1500° F. oil-quenched. Case depths .008" to .012". All parts cadmium plated after casing in free-cleaning PK-5C.

Screw nut SAE 1118 oil quenched from PK-5C at 1550° F. 2 hours .020" case depth. Jack screw SAE 1027. In PK-5C for 20 min. roller quenched in oil. Pieces washed and plated.

Pinking shear blades .014" case in 1 hour at 1600° F. in PK-5C. Oil quench.

HEAT TREAT SUPERVISORS tell us that Park-Kase 5-C gives them absolutely trouble-free salt bath liquid carburizing; cuts time all around; requires no skilled help, yet assures accurate control.

EVEN THE MOST INTRICATE PARTS can be quickly cleaned from water-soluble Park-Kase 5-C, emerge with a gleaming, silvery finish, suitable for plating or not, as required.

FAST, REPRODUCIBLE CASES can be easily held to close limits for accurate, dependable work at temperatures up to 1750 degrees.

NON-HYGROSCOPIC PARK-KASE 5-C won't corrode metal pots, fixtures or finished work; won't precipitate sludge; won't foam during operation or while additions are being made. A carbon cover forms to protect men from excessive heat and fumes.

An extremely fluid bath, Park-Kase 5-C requires a light-weight original charge and maintains efficient carburizing activity by the replenishment of normal dragout. Park-Kase 5-E Energizer is added where conditions of unusually low replenishment are present.

Send for new 4-page technical bulletin.

NEW! THERMO-QUENCH OIL

. . . exceptional stability and resistance to oxidation for quenching in oil from 300° to 900°F—Bulletin P-7.

Park CHEMICAL COMPANY
8074 MILITARY AVE.
DETROIT 4, MICH.

INDUCTION HEAT

PERMITS 2 OZ. TOLERANCE

ON HIGH SPEED FORGING PRESS

It previously took 8 to 10 drops of a hammer, with slow flow of metal, to achieve close tolerances required for connecting rod forgings. But this leading automobile plant recently combined scale-free, closely controlled Ajax-Northrup heat with improved die design, and pioneered the development of rods *press-forged* at unheard-of production rates.

Clean, fast induction heat now saves tons of steel yearly in many forge shops. Increases die life as much as 20%. No abrasive scale, and accurate timing prevents overheated dies. A bank of Ajax-Northrup heaters at each machine handles several sizes of stock, heating variable lengths with quickly adjustable timing and feeding devices so that jobs can be changed in a jiffy. Saves start-up time; the first hot billet is ready in seconds. No need to "pull" stock during shut-downs—just push the "off" button instead. Working conditions are better, too.

Whether you want to improve quality or reduce costs, you'll find the right answer in Ajax-Northrup. Over 33 years experience in successful induction heating and melting.

AJAX ELECTROTHERMIC CORPORATION

AJAX PARK, TRENTON 5, N. J.

SINCE 1916

Associate Companies

THE AJAX METAL COMPANY • AJAX ELECTRIC FURNACE CORPORATION
AJAX ELECTRIC COMPANY, INC. • AJAX ENGINEERING CORPORATION

AJAX NORTHRUP
HEATING & MELTING

119

2 NEW COMPACT KEMP ATMOSPHERE GENERATORS OFFER PUSH BUTTON STARTING, FOOL-PROOF OPERATION

IF YOU need a compact source of atmosphere gas, *save time and money*, specify Kemp! Two new Kemp Atmosphere Generators (models MIHE-1 and 2) deliver 1000 and 2000 cfh respectively. Both offer all features of larger equipment: push button starting, automatic fire check, flow meter, etc. . . and assure that you get *same analysis* gas from 1% to 100% of capacity.

FOOL PROOF OPERATION

Kemp Generators burn ordinary gas just as it comes from the mains. A famous Kemp Carburetor, part of each installation, assures *complete combustion* without "tinkering" to produce a clean, chemically inert gas containing 88% nitrogen, 12% CO^2 . . . a gas so pure it is used *without further processing* in copper annealing and in the manufacture of *aspirin* and *laboratory chemicals*, fine paints and a host of other products.

WRITE FOR DATA

Whether you need inerts for purging, fire protection . . blanketing or any steel application . . . specify Kemp. For technical information write for Bulletin 1-11. *To find out how you can benefit:* Tell us how you produce atmosphere gas now; we'll show you how Kemp can solve your problem. *Mail Coupon today!*

KEMP *ATMOSPHERE GAS GENERATORS*
OF BALTIMORE

CARBURETORS
BURNERS
FIRE CHECKS
ATMOSPHERE GENERATORS
ADSORPTIVE DRYERS
METAL MELTING UNITS
SINGEING EQUIPMENT
SPECIAL EQUIPMENT

THE C. M. KEMP MFG. CO., Dept. D-7
403 E. Oliver St., Baltimore 2, Md.

Gentlemen: Send me information on Kemp Generators. I am interested in Bulletin 1-11; data on larger equipment.

Name .....
Company .....
Address .....
City ..... Zone ..... State .....

Metal Degreasing

(Starts on page 77)

central nervous system. When inhaled, their vapors can cause irritation of the mucous membrane of the lungs, loss of consciousness and death by asphyxiation. In common with other degreasing agents, solvents cause varying degrees of dermatitis, and, once damaged, the skin becomes more susceptible to further injury from mechanical abrasion, heat, radiation, allergents, chemical irritants and secondary infections.

Volatile solvents enter the body chiefly through the respiratory passages; however, appreciable amounts may be absorbed through the skin. Inhaled vapors of a solvent pass directly into the general circulation and are distributed to the heart and the central nervous system. They may produce a general toxic effect without injuring the respiratory tract, or a mixed effect, including local irritation.

It is important in industry to recognize any signs of toxic reactions as early as possible, in order to institute proper measures for their control. The effects of overexposure to a solvent vapor are not always specific, especially in early stages or exposure to limited concentrations. Irritation or depression of the central nervous system may cause a diversity of symptoms which may lead to classifying an employee as neurasthenic, eccentric, intemperate or lazy. Gastrointestinal irritation with nausea, vomiting and abdominal pain is frequently seen with different types of intoxication. Damage to liver, kidney, heart, blood and blood-generating organs are more specific, but are not typical of intoxication to any one solvent.

Naphtha — In manufacturing plants, a naphtha of high flash point is generally the petroleum solvent used for degreasing purposes. Such a solvent has the advantage of a relatively low toxicity (maximum allowable concentration* — 500 parts per million parts of air). On the other hand petroleum naphthas are flammable, and fire and explosion hazards attend their use. The effects of toxic quan-

*Threshold limit adopted at American Conference of Governmental Industrial Hygienists, 1948.

(Continued on page 104)

LEPEL *offers a New*

LOW COST *High Frequency* HEATING UNIT

AT A PRICE SO LOW THAT NO MACHINE SHOP, TOOL ROOM OR LABORATORY CAN AFFORD TO BE WITHOUT IT!

Unit illustrated brazing carbide tips to cutting tools. Shanks up to 1½" square can be satisfactorily brazed.

- **SMALL and COMPACT** — Conveniently operated on bench or table — no mounting necessary.
- **ECONOMICAL OPERATION** — No special power installation required. Operates on 110 volts, 60 or 50 cycle line at unity power factor.
- **FULLY GUARANTEED** — Guaranteed for continuous duty cycle and stated performance.
- **LOW COST** — Complete unit with line connection and load coil $780.00 f.o.b. factory

DOES ALL THESE JOBS *Faster, Better and Cheaper*

BRAZING, SOLDERING HARDENING, ANNEALING DRAWING AND MELTING

WILL HEAT TO 1500° F.

¼" steel rod 1" length ... seconds

½" ... 3 seconds

½" ... 10 seconds

1" ... 60 seconds

Will melt 4 ounces of brass or steel in 4 minutes.

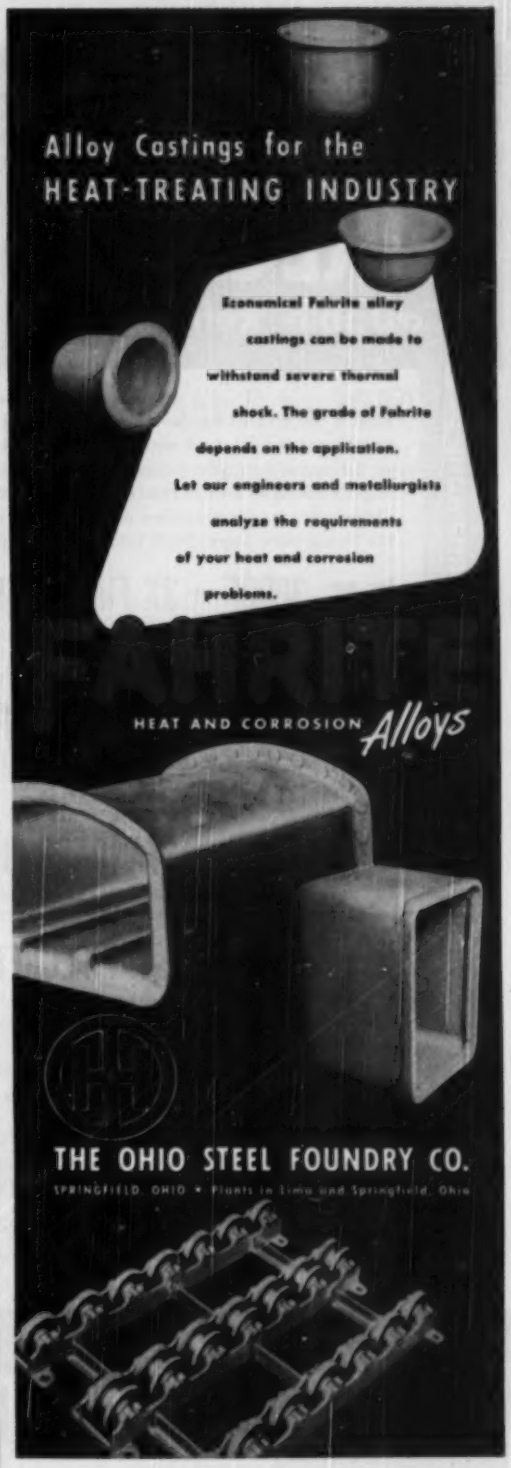
Equally well suited for heating of non ferrous metals.

Lepel

HIGH FREQUENCY HEATING UNITS

LEPEL HIGH FREQUENCY LABORATORIES, Inc. 39 West 60th Street, New York 23, N. Y.

◆ ◆ WRITE FOR LEPEL CATALOG MP-7 ◆ ◆


Alloy Castings for the
HEAT-TREATING INDUSTRY
Economical Fahrite alloy castings can be made to withstand severe thermal shock. The grade of Fahrite depends on the application. Let our engineers and metallurgists analyze the requirements of your heat and corrosion problems.
HEAT AND CORROSION Alloys
THE OHIO STEEL FOUNDRY CO.
SPRINGFIELD, OHIO • Plants in Lima and Springfield, Ohio

CAST SPECIAL SHAPES QUICKLY . . . EASILY

. . . with these

FIRECRETE

Castable Refractories

Check the job to be done and you will find a Firecrete* product that will do it well. For special refractory shapes or linings it's simply mix and cast. The new shape or lining air-hardens and is ready for service within 24 hours. Other advantages include—no drying shrinkage, negligible firing shrinkage, high resistance to spalling.

For use up to **3000F — 3X FIRECRETE**

This new member of the Firecrete family effectively withstands soaking temperatures up to a full 3000F. Provides savings through longer life and reduced shutdowns.

For use up to **2800F — H-T FIRECRETE**

A high heat-duty refractory composed of an exceptionally heat-resistant base. Specially developed for service between 2400F and 2800F.

For use up to **2400F — STANDARD FIRECRETE**

The most generally applicable type of Firecrete. Finely ground, permitting casting of shapes or linings as thin as 1½".

For use up to **2400F — L-W FIRECRETE**

A lightweight insulating refractory concrete with unusually low thermal conductivity, low heat storage capacity and high resistance to spalling.

The above Firecrete materials can be used in combination where varying temperature and service conditions are encountered.

For patching and gunning, use 3X BLAZECRETE. For temperatures to 3000F. It has exceptional adherence qualities, can be flipped into place with a trowel without ramming or tamping.

For further information, write to Johns-Manville, Box 290, New York 16, N. Y.

JM

*Reg. U. S. Pat. Off.

Johns-Manville

FIRECRETE

"The Standard in Castables"

Metal Degreasing

(Starts on page 77)

lities on personnel may be visual disturbances, headache, dizziness, drowsiness, nausea, vomiting, and sometimes a condition resembling alcohol intoxication. Acute exposures may result in asphyxiation.

In the plants investigated, the solvent was used for degreasing small metal parts only. Usually, the solvent was held in safety cans, and inhalation of vapor presented a greater hazard than the possibility of fire. For such application, except for certain discontinuous processes, mechanical ventilation should be supplied to keep vapor concentration below safe limits. This control measure not only will reduce the inhalation hazard but will also reduce the possibility of explosion.

Under no conditions should personnel use petroleum naphtha in confined spaces without adequate mechanical ventilation, unless an air mask is worn. The same rule applies to the operation of cleaning solvent tanks and containers. Finally, safety containers should be used to hold the solvent and flat open pans avoided.

Gasoline — While the toxicity of lead-free gasoline is in the same general range as the petroleum naphtha, it is a highly volatile, flammable substance which gives considerable hazard, both fire and health, under the usual condition of use. The effects of toxic quantities are similar to those of naphtha. A safer solvent can usually be found.

Leaded gasoline presents the additional hazard of exposure to toxic lead compounds. It should never be used for cleaning or degreasing, and effort should always be made to avoid prolonged skin contact or inhalation of its vapors.

Trichloroethylene — Certain chlorinated solvents have also been found excellent degreasing agents and possess the added advantage of being nonflammable at working temperatures. Recent investigations in northwestern Pennsylvania have shown that of the chlorinated degreasing solvents, trichloroethylene is used in the greatest number of plants. In 29 plants investigated, 27 were using trichloroethylene, one was using carbon tetrachloride, and one was using perchloroethylene. While an insufficient number of installations were investigated for a statistical study, *(Cont. on p. 106)*

A Lubricant that Works from sub 0 to 3000 plus

ORDINARY lubricants gum up at extremely low temperatures or break down at extremely high temperatures . . . but not Acheson's specially processed **"dag"** colloidal graphite!

This versatile material is dispersed in organic and inorganic carriers for positive transmission to the zone of lubrication . . . for effective concentration at those points . . . for friction-fighting that can't be beat!

"dag" colloidal graphite is unique in its combination of properties and uses. It is very slippery and extremely durable, anti-corrosive, gas adsorbent, chemically inert and, of course, highly resistant to heat.

In deep piercing you get smooth forgings, close tolerances and reduced wear on dies. In casting and mold stripping you get smooth surfaces, clean parting, fewer rejects; and additional mold life.

In forging you minimize scaling and sticking, improve finish, lengthen die life.

In stretch-forming you reduce tearing and rippling. In wire-drawing you get uniform diameter, better finish and greatly extended die life.

Brass, bronze, aluminum, magnesium, carbon steel and stainless steel . . . wherever your fabrication problems are friction and heat . . . **"dag"** colloidal graphite reduces the one and resists the other.

The NEW Acheson Bulletin #426 on the Use of **"dag"** Colloidal Graphite in Metalworking operations is just off the press . . . a copy is ready for you if you will fill in and mail the coupon.

Acheson Colloids is equipped to do custom disintegrating, dispersing, and stabilizing of solids in a wide variety of vehicles. If you are in need of this type of service, tell us about it. We may be able to help you.

ACHESON COLLOIDS CORPORATION
Port Huron, Michigan

☐ Send me the NEW Metalworking Bulletin #426

☐ Send an Acheson engineer

NAME.....

COMPANY.....

STREET.....

CITY..... ZONE.....

STATE.....

G-10

dag DISPERSIONS

Acheson Colloids Corporation, Port Huron, Michigan

. . . also Acheson Colloids Limited, London, England

OVER ONE HUNDRED YEARS OF CONTINUOUS SERVICE ROUNDS, SQUARES, FLATS, HEXAGONS, OCTAGONS

Get your
STANDARD ALLOY STEEL
from the same reliable source
as HY-TEN ALLOY STEEL

Although perhaps best known for our *special* HY-TEN Alloy Steels, Wheelock, Lovejoy carries a full line of *standard* steels *in stock* for fast, dependable service from our warehouses. These standard grades include: C-1117, A4615, E4617, A4620, A4140, A4142, A4145, A4150, A4340, etc.

There are many advantages in using a single source for all your alloy steel needs, and Wheelock, Lovejoy offers these extra services — modern heat treating, testing and cutting, plus prompt delivery of blocks, rings, spindles and other forged shapes to your exact specifications.

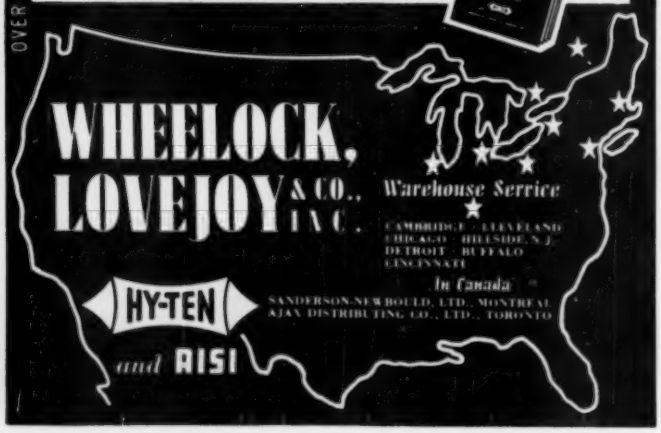
Call in your nearest Wheelock, Lovejoy metallurgical expert – he represents a firm that is backed by over a century of experience in the use and application of fine steels.

WL *steels are metallurgically constant. This guarantees uniformity of chemistry, grain size, hardenability — thus eliminating costly changes in heat treating specifications.*

Write today for your FREE COPY of the Wheelock, Lovejoy Data Book, indicating your title and company identification. It contains complete technical information on grades, applications, physical properties, tests, heat treating, etc.

134 Sidney St., Cambridge 39, Mass.
and Cleveland • Chicago • Detroit
Hillside, N. J. • Buffalo • Cincinnati

BILLETS AND FORGINGS FOR PRODUCTION, TOOL ROOM AND MAINTENANCE REQUIREMENTS



Metal Degreasing

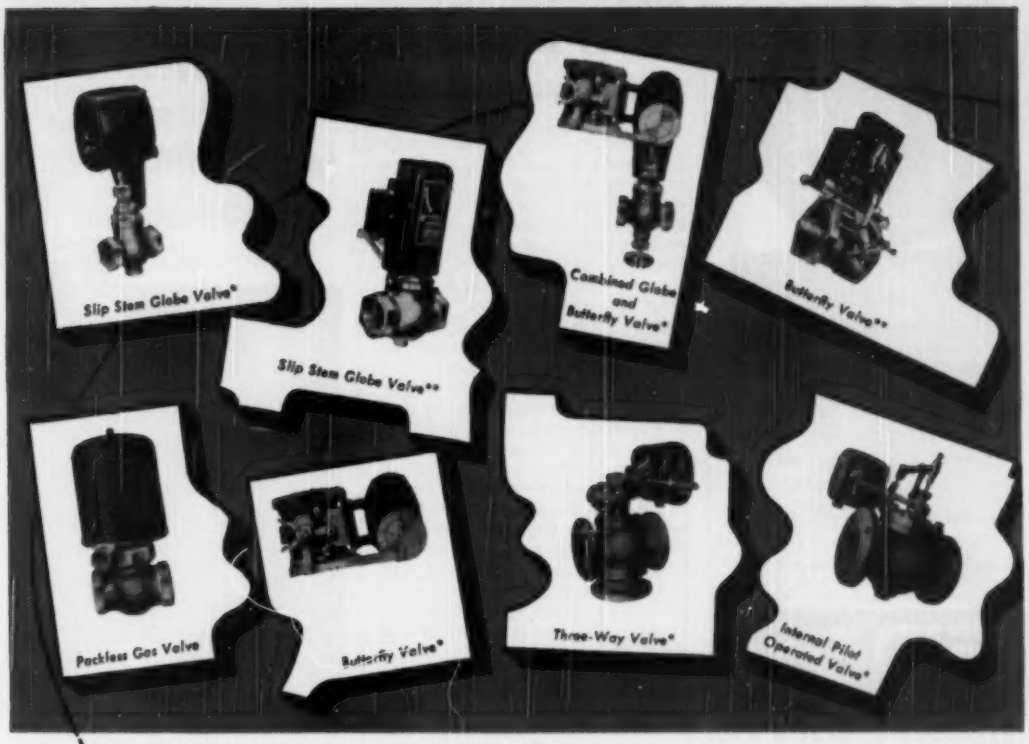
(Starts on p. 77) findings are in agreement with the study made by K. M. Morse and L. Goldberg.*

Of the 27 plants using trichloroethylene, 23 were degreasing in the familiar dip tanks equipped with condensing coils at a point below the top of the tank, and four were using enclosed degreasing apparatus, through which the work was carried by a conveyer belt or chain. All the dip tanks employed vapor phase degreasing and three of the tanks were fitted for washing with a liquid solvent hosed on the work while it was still suspended in the tank at a point below the level of the condenser coil.

Average concentrations of airborne solvent at the breathing level of the operators at the various machines, including enclosed ones, ranged from 13 to 260 parts per million. Weighted average exposures based on an 8-hr. work day and the actual time which operators were exposed per day did not exceed 82 parts per million. The reduction in weighted exposures as compared with actual concentrations found at the tanks was due in part to the fact that the operator did not spend all of his time in areas of high concentration, and also to the fact that machines often were not used continuously. In several small plants (100 to 400 employees), degreasers were used as little as 3 hr. per day, and in two plants were used as little as 6 to 8 hr. per week. In some of the plants, if the degreaser were used steadily, as during war years, under conditions as noted during the investigation, it is probable that weighted exposures would be higher than the allowable limit of 100 parts trichloroethylene per million parts of air.

The range of the average concentration of solvent vapor at the breathing level at ventilated dip tanks was 13 to 72 parts per million, as compared with a range of 15 to 260 parts per million for unventilated tanks. The range of average concentrations at the operator's breathing level for the enclosed automatic machines was 33 to 82 parts per million. In connection with the dip tanks it was also noted that the speed of movement of work into and out of the tank had considerable *(Cont. on p. 108)*

**Industrial Medicine*, October 1943.



*Powered by Heavy Duty Industrial Motor **Powered by Modutrol Motor

For better results at lower costs
FIT THE VALVE TO YOUR PROCESS

VITAL to optimum operation of any control system is the selection of the proper valve for each application. What is gained through the superiority of the process equipment and its control may be lost through poor selection or sizing of the valves.

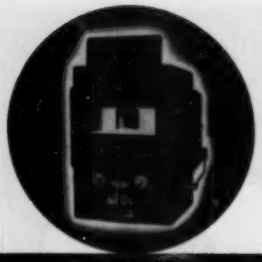
Proper valve selection often is difficult. The type of inner valve, motor timing, torque rating, material and size . . . all must be chosen to fit the process conditions. Particular care should be given to valve sizing . . . for a valve can perform best only when it is properly sized.

Your local Honeywell engineer is qualified to render expert advice, will gladly help you select the correct valve for each specific application. The completely integrated line of Honeywell motorized control valves, a few of which are illustrated, enables him to make unbiased recommendations.

For further information, call in your local Honeywell engineer . . . he is as near as your phone! Or write for Catalog 8202. MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4503 Wayne Ave., Phila. 44, Pa. Offices in more than 80 principal cities of the United States, Canada and throughout the world.

FOR METAL PROCESSING

Honeywell
BROWN INSTRUMENTS

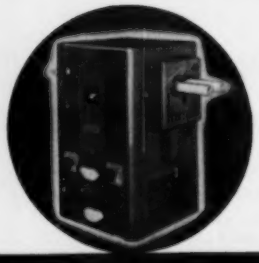


BURRELL
BOX and MUFFLE
FURNACES

HIGH TEMPERATURE "UNIT-PACKAGE" ELECTRIC BOX and MUFFLE FURNACES for melting, sintering, heat treating, ignitions, etc.

Write for Bulletins 315 and 515.

BURRELL
1942 FIFTH AVE
PITTSBURGH 19
PENNSYLVANIA



BURRELL
TUBE FURNACE

HIGH TEMPERATURE "UNIT-PACKAGE" ELECTRIC TUBE FURNACES for determination of carbon or sulfur by combustion and for experimental or production purposes.

Write for bulletin 310.

BURRELL
1942 FIFTH AVE
PITTSBURGH 19
PENNSYLVANIA

Metal Degreasing

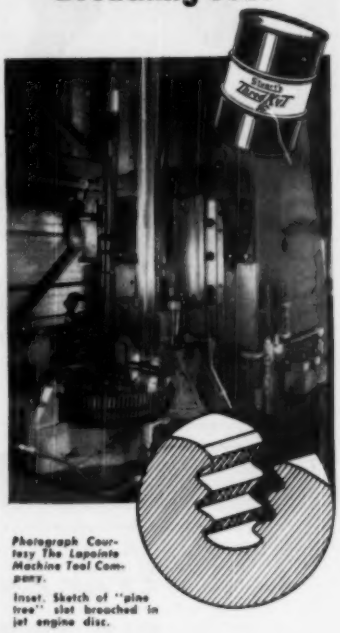
(Starts on p. 77) influence on the concentration of solvent in air, as evidenced by the range of average concentration of 10 to 300 parts per million for introduction of work into the tanks, and a range of 17 to 310 parts per million for removal of work. For these same tanks average concentrations of air-borne solvent during idling, or while load was being degreased, ranged from 13 to 185 parts per million.

From our observations it has been evident that care must be used in placing a load in the degreaser and in removing it from the degreaser. In this respect we concur with Morse and Goldberg in recommending 20 ft. per min. as the limiting speed for movement of the load, with 12 ft. per min., or less, preferred. We also recommend that care be exercised in maintaining condensing water at correct temperature, that loads be properly placed in baskets to allow complete drainage before removal from the tank, that automatic controls be used for maintaining proper solvent and solvent vapor temperature, that tanks be placed or guarded so as to prevent the effects of strong air currents blowing across the top of the tank, that tanks be placed where good general ventilation is available, and that operators be carefully instructed in proper operation of the degreasing tank. (This latter recommendation is one of the most important.) Care should also be used to avoid contact of solvent vapor with open flames or hot surfaces, because the products of decomposition of the solvent are toxic and irritating. In addition the decomposition products are corrosive to other materials and their control is, therefore, of direct economic importance.

Finally, every precaution should be taken during the necessary periodic cleanout of the tanks. In the performance of this task, personnel may be exposed to heavy concentrations of vapor, elimination of which is difficult by the usual mechanical ventilation. For safety, workmen so exposed should be furnished air masks and should work in pairs so that one may assist the other if an accident does occur.

Local exhaust ventilation has not been included as a general recommendation. Our findings have shown various *(Cont. on p. 109)*

"ThredKut 99
Smooths out
tough "PINE TREE"
Broaching Job!



Photograph Courtesy The Lapointe Machine Tool Company.

Inset. Sketch of "pine tree" slot broached in jet engine disc.

HERE is one of the most difficult broaching jobs that the metal-working industry has ever tackled and solved — cutting the "pine tree" shaped slot in exceptionally tough alloy steel jet engine discs.

Stuart's THREDKUT 99 has rendered outstanding service for leading manufacturers in this field. Its combination of high anti-weld and high lubricity characteristics proved to be a 100% satisfactory solution to difficulties of this job.

What is your broaching job? The toughest ones can be handled better, and the easy ones are easier with the right Stuart products! Ask for Stuart's pamphlet OILS FOR BROACHING or call your nearby Stuart representative.

D.A. Stuart Oil Co.
2473 So. Troy St., Chicago 23, Illinois

ACP

PHOSPHATE FINISHES TO MAKE YOUR PRODUCT *DURABLE*

PAINT BONDING

"Granodine" forms a zinc-iron phosphate-coating bond on sheet metal products — automobile bodies and fenders, refrigerator cabinets, etc. — for a durable, lustrous finish.

"Lithoform" makes paint stick to galvanized iron and other zinc and cadmium surfaces.

"Alodine", the new ACP protective coating chemical for aluminum, anchors the paint finish and protects the metal.

RUST PROOFING

"Permadine", a zinc phosphate coating chemical, forms on steel an oil-adsorptive coating which bonds rust-inhibiting oils such as "Granoleum."

"Thermoil-Granodine", a manganese-iron phosphate coating chemical, forms on steel a dense crystalline coating which, when oiled or painted, inhibits corrosion.

PROTECTION FOR FRICTION SURFACES

The oiled ***"Thermoil-Granodine"*** coating on pistons, piston rings, cranks, camshafts and other rubbing parts, allows safe break-in operation, eliminates metal-to-metal contact, maintains lubrication and reduces the danger of scuffing, scoring, galling, welding and tearing.

IMPROVED DRAWING AND EXTRUSION

"Granodraw" forms on pickled surfaces a tightly-bound adherent, zinc-iron phosphate coating which facilitates the cold mechanical deformation of steel, improves drawing, and lengthens die life.

Write or call for more information on these products. Send for new descriptive folder on ACP Metal-Protective and Paint-Bonding Chemicals.

American Chemical Paint Co.
AMBLER PENNA

Metal Degreasing

(Starts on p. 77) instances in which dip tanks with condensers have been operated so that maximum allowable concentrations of solvent were not exceeded during operation. However, installations should be considered individually, and local exhaust ventilation provided where needed.

The symptoms of overexposure to trichloroethylene are irritation of the respiratory passages, dullness, dizziness, vomiting, stupor, and in acute exposures, unconsciousness, and death. The compound resembles chloroform and carbon tetrachloride in anesthetic effect, but it does not appear to cause liver damage. It may be absorbed through the skin as well as by respiratory organs.

Perchloroethylene is used for metal degreasing to a much lesser extent than trichloroethylene. The maximum allowable concentration of the vapor in the breathing atmosphere is 100 parts per million. Exposures of personnel to excessive concentrations of air-borne compound may give irritation of the mucous membrane, nausea and vomiting, loss of consciousness, and possible symptoms of liver, kidney and heart damage. Our investigations have shown that where it is used in a degreasing tank, the same care and caution must be observed in controlling exposures as when trichloroethylene is the solvent. We also found that the portable units designed for use with this solvent, and which were not equipped with condensers or exhaust ventilation, were, in general, provided with insufficient control apparatus to prevent accumulation of dangerous amounts of perchloroethylene in the air. These findings substantiate those of R. C. Crowley, C. B. Ford, and A. C. Stern.*

Carbon tetrachloride is a chlorinated hydrocarbon for which the maximum allowable concentration in the breathing atmosphere is 50 parts per million. It was formerly used to some extent in degreasing machines but proved unsuitable for such purpose. In our investigations we have noted it being used solely in degreasing operations involving brushing or wiping the article with solvent. Its toxicity requires that excellent general *(Cont. on p. 111)*

**Journal of Industrial Hygiene and Toxicology*, 1945.

At Fred Heinzelman & Sons
NEW YORK, N.Y.

Pangborn Hydro-Finish CUTS HAND POLISHING OF DIES 60%
reports Mr. J. L. Crosby, General Manager

***Shown here** is the Pangborn Hydro-Finish unit which set new records at Fred Heinzelman & Sons. A pioneer of heat treated dies, the company reports: Hydro-Finish removes heat treat oxide discoloration, cuts hand polishing 60% to 70%, holds tolerances to a precision .0001"!*

Find out how HYDRO-FINISH *can save you money*

Hydro-Finish is the answer to modern cleaning, decorating and finishing problems. As Fred Heinzelman & Sons have found, Hydro-Finish virtually eliminates tedious and expensive hand buffing and polishing on tool and die maintenance. Now, dies with heavy oxide discolorations can be cleaned faster and at lower cost.

And, on the production line, Hydro-Finish assures better bonding, electroplating, painting—gives you ***the surface you want*** within .0001" with no pits, grooves or hard-to-clean imperfections left after cleaning.

For full information on the many ways Hydro-Finish can save you money, write today for Bulletin 1400 to: PANGBORN CORPORATION, 1204 Pangborn Blvd., Hagerstown, Md.

Pangborn
BLAST CLEANS CHEAPER
with the right equipment for every job

the mountain comes to

Mohammed!

THOUSANDS OF MEN* INTERESTED IN METALS VISIT THE

METAL SHOW

TO GET YOUR HELP IN ACHIEVING "ECONOMY-IN-PRODUCTION"

● The Metal Show is Tops! At the Metal Show in Cleveland last fall 35,588 men viewed the exhibits—for years, the attendance of Executives, Metal Engineers and Buying Officials has exceeded 30,000. The Metal Show in Chicago next October will draw at least 30,000 men that are interested in anything and everything that will help them achieve "Economy-in-Production".

And these men BUY! For example: 22% of last year's visitors decided to buy something they saw at the Metal Show. 10% bought something different from what they planned after seeing it at the Metal Show. And 20% completed a decision to buy something after seeing it displayed at the Metal Show.

Nearly 400 manufacturers will exhibit at the Show. Be among them and secure your space NOW. Write, wire or phone W. H. Eisenman, Managing Director, 7301 Euclid Avenue, Cleveland 3, Ohio, (UTah 1-0200) for floor plan and space reservation.

***35,588 Metal Men attended the Show in Cleveland last fall. Attendance Report No. 4 tells why they came, when they came, how long they stayed and what they thought. If you haven't received your copy, write for it.**

METAL SHOW

OCT. 23-27, 1950

INTERNATIONAL AMPHITHEATRE, CHICAGO, ILL.

Sponsoring Societies

American Society for Metals
Institute of Metals Div.—A.I.M.E.
American Welding Society
Society for Non-Destructive Testing

Metal Degreasing

(Starts on p. 77) ventilation or local exhaust ventilation be provided for control of exposures during degreasing. Where it cannot be handled with safety, some other less toxic solvent should be substituted or the operations redesigned. Where carbon tetrachloride is used under unsafe conditions, personnel exposed should be furnished with fresh air hose masks.

Carbon tetrachloride has one of the lowest allowable limits of the degreasing solvents. In excessive concentrations it may cause symptoms similar to those of trichloroethylene with additional symptoms of damage to the liver, kidney and heart. Early evidence of excessive concentrations may be irritation of the eyes and respiratory passages, headaches, and disturbances of the stomach.

Chlorinated Solvent Mixtures—Our investigations revealed some use of chlorinated hydrocarbons in mixed solvents. This was noted particularly in connection with garages where such a solvent mixture has proved effective not only in removing grease, but also in removing gummy deposits from pistons and other parts of internal combustion motors. The solvent has generally been used in small, plain, rectangular tanks, although a pump may be added to the tank to allow for hose spraying of the liquid on the metal part.

Actual exposures of personnel to toxic vapors may be highly variable for installations of this type, owing to the variability in the amount of work being performed. For safety, the installations should be checked by trained industrial hygiene personnel, and control measures added as shown necessary by determination of exposures.

Chlorinated hydrocarbons have also been added to other solvents—for example, petroleum naphthas—to provide a metal degreasing mixture that would not be so flammable as the naphtha alone. Where such mixtures are used, control is usually necessary to prevent hazardous exposure to the chlorinated compound. In addition, the vaporization characteristics of the mixture should be well known in order to avoid the possibility that all of the chlorinated compound may be evaporated, leaving a highly flammable solution.

LOW-COST HYDROGEN AND NITROGEN

YOU effect real economies when you use Barrett Standard Anhydrous Ammonia as a replacement for other more expensive sources of hydrogen and nitrogen.

Barrett Standard Anhydrous Ammonia (Refrigeration Grade) contains a minimum of 99.95% NH_3 and is oxygen free with a very low dew point. When dissociated, each pound produces approximately 34 cubic feet of hydrogen and 11 cubic feet of nitrogen.

Engineers have discovered many advantages from the use of dissociated ammonia in the production of controlled atmospheres in furnaces for bright annealing, clean hardening, copper brazing, sintering, reduction of metallic oxides, atomic hydrogen welding, radio tube sealing and other metal-treating practices. Anhydrous ammonia also has unsurpassed qualities in nitriding of steel, used as ammonia gas or dissociated.

Barrett Standard Anhydrous Ammonia is available in 150, 100 and 50-pound cylinders from stock points conveniently located from coast to coast; or, for larger users, in tank car shipments from Hopewell, Virginia, and South Point, Ohio.

The advice and help of Barrett technical men are available to Barrett customers without charge. For information, contact Barrett, *America's leading distributor of ammonia.*

THE BARRETT DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 RECTOR STREET, NEW YORK 6, N.Y.
*Reg. U. S. Pat. Off.

Stress Relief, Especially of Weldments

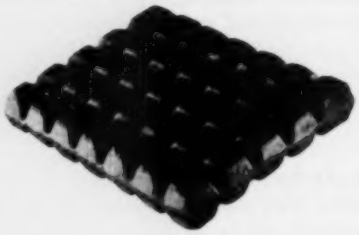
(Continued from page 80)

"We also make casing to be put into the drilled oil well. The steel in this pipe has a yield point of about 45,000 psi. This pipe is compressed about 6% and the yield point in compression is raised above 80,000 psi. In this manner the casing is increased in collapse value by 20 to 35%.

"The proof that residual stresses are practically eliminated is obtained by cutting short rings from such pipe both stretched and compressed and splitting them by a saw cut. If the cut does not open or close, the fact that the residual stresses are practically eliminated is demonstrated. Normally if a piece of pipe is so split which is in the as-welded condition, the ends will spring open or come together a considerable amount.

"The next structure where overstressing reduces residual stresses is that of the pressure vessel. We have for a considerable time tested these vessels to twice the working pressure. The general factor of safety used in America is 4 on the minimum specified strength. The yield strength of normal pressure vessel steels is roughly 55% of the ultimate strength. If, therefore, there is high residual stress in such a vessel due to fabrication, it is smoothed out by the pressure test. The proof: No one can fabricate a pressure vessel without incurring residual stresses, yet many pressure vessels are not stress relieved by heat. After the test value of twice the working pressure is imposed we have tested several to failure. The pressure-volume curve of such tests shows that the yield and ultimate strengths of the vessel practically coincide with the figured yield and ultimate stresses of the steel. The openings in such vessels need be reinforced and heads need be properly shaped to produce these results." (End of Mr. Jasper's letter to Professor Soete of the Belgian Institute of Welding.)

(Continued on page 114)



A Little Does a Lot

GCC CERIUM METAL (Mischmetal) added in small quantities to many Ferrous and Non-Ferrous Metals improves the metallurgical and mechanical properties of the end products.

Discover how a little does a lot by writing for our informative bulletins.

GCC GENERAL CERIUM CO.
EDGEWATER, NEW JERSEY

YOUR HARDNESS TESTER...

IS ONLY AS GOOD AS THE DIAMOND IT USES

Standard "C" Diamond Cone
$18.00 F. O. B. Detroit

Dependably accurate "Rockwell" testing results are obtained only when every part of your hardness testing equipment is made to precision limits. That is why a correctly designed diamond penetrator is of such great importance. Always specify CLARK Diamond Cone Penetrators, both for Standard and for Superficial "Rockwell" testing. They are accurately made to the proper size and shape; exactly formed by expert lappers. CLARK Penetrators are designed for use on all "Rockwell" type testing machines.

CLARK
TOMORROW'S ACCURACY TODAY
INSTRUMENT, INC.
10200 FORD ROAD
DEARBORN, MICH.

Bulletin on SUPER REFRACTORIES by CARBORUNDUM

TRADE MARK

NO. 9 JULY, 1930

What Are the Fields of Application for Super Refractories?

Super refractories by CARBORUNDUM have been used with excellent results in a wide range of industrial kilns and furnaces and for certain other specialized applications. They have demonstrated that, wherever refractories are used, it is possible that *super refractories* may be profitably adapted to specific areas of recommended usage.

However, in spite of their wide range of use, there is no pat formula for application — each new installation must be considered individually. Service requirements vary so between units, that even comparable furnaces may develop conditions demanding the use of different super refractories. Actual selection of super refractories can be based only on the specific operating conditions involved.

The field of application for super refractories is limited only by the economic justification of their cost. In some installations they are used to implement other refractories to improve overall life. In still other cases they may completely replace common refractories to increase production, improve quality of work and even make new processes possible.

At the right are some of the applications in which their special properties are used to good advantage.

Physical Properties of Super Refractories by CARBORUNDUM

Trade Mark

	CARBOFRAX Silicon Carbide	MULLFRAX Electric Furnace Mullite	MULLFRAX S Converted Kyanite	ALFRAX K	ALFRAX B	ALFRAX BI
				Electrically Fused Alundum		
Heat Conductivity at 2200° F. in BTU/ hr. sq. ft. and °F. /in. of thickness	109 BTU	16 BTU	9 BTU	24 BTU	12 BTU	7 BTU
REFRACTORINESS PCE CONE	37-40	38-39	37-38	37-39	39-40	38-39
SPALLING RESISTANCE	High	High	High	Good	Good	Good
ABRASION RESISTANCE	High	Medium	Medium	High	Medium	Low
THERMAL EXPANSION (25° — 1400° C.)	.0000044	.0000059	.0000069	.0000074	.0000086	.0000086
MODULUS OF RUPTURE @ 2400° F. PSI	800-3125	100-250	175-475	100-1050	100-225	50-100
WEIGHT 9 IN. STRAIGHT	9.25 lbs.	9 lbs.	8 lbs.	10.1 lbs.	7.25 lbs.	4.8 lbs.

Some of the Applications For Super Refractories

Acetylene manufacturing furnaces
Activated carbon retorts
Air furnaces
Aluminum melting furnaces
Annealing furnaces
Assay furnaces
Baking ovens
Billet heating furnaces
Boiler settings
Bone char revivification furnaces
Brass melting furnaces
Butadiene manufacturing furnaces
Cadmium retorts
Carbon brush furnaces
Carbon black furnaces
Carbon monoxide furnaces
Carbon dioxide furnaces
Carburizing furnaces
Cement kilns
Ceramic kilns
Coal gas benches
Cobalt retorts
Copper melting and refining furnaces
Crucible melting furnaces
Cupolas
Electric furnaces
Enamel frit furnaces
Forging furnaces
Gas producers
Gas generators
Glass tanks
Glass lehrs
Gold smelting furnaces
Heat treating furnaces
Hydrocarbon cracking furnaces
Hydrogen manufacturing furnaces
Incinerators
Ladles
Lime kilns
Lithopone kilns
Malleable annealing furnaces
Magnesium reduction furnaces
Muffle furnaces
Muriatic acid furnaces
Oil refining stills
Oleum manufacturing furnaces
Open hearth furnaces
Phosphate furnaces
Porcelain enameling furnaces
Pottery kilns
Recuperators
Regenerators
Reheating furnaces
Retorts
Reverberatory furnaces
Rock wool furnaces
Rotary kilns
Slag wool furnaces
Smelting furnaces
Soaking pits
Styrene manufacturing furnaces
Sulphur burners
Tunnel kilns
Varnish fires
Welding furnaces
Zinc distillation
Zinc refining
Zinc retorts

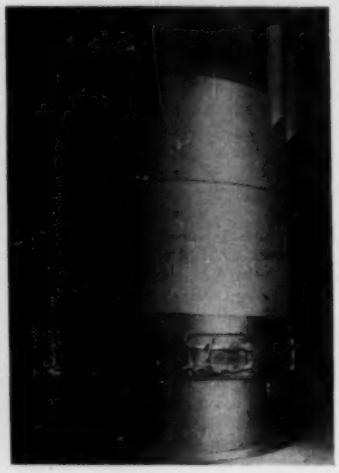
"Carborundum," "Carbofrax," "Mullfrax," "Silfrax," "Alfrax" are registered trademarks which indicate manufacture by The Carborundum Company

Address all correspondence to: Dept. C-70, THE CARBORUNDUM COMPANY, Refractories Division, Perth Amboy, New Jersey

Continued on other side →

← Continued from other side

Water Gas Generators — Another Super Refractory Application



Four principal benefits result when water gas generators are equipped with CARBOFRAX silicon carbide linings:

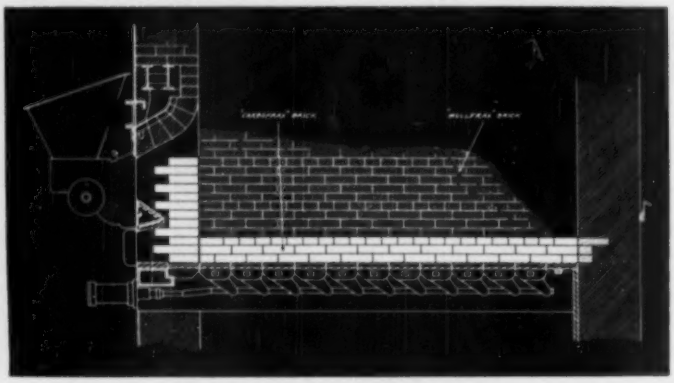
1. Faster and Easier Cleaning: Clinkers do not become embedded in the hard brickwork. Barring off is faster, easier and more complete. Cleaning time is reduced 30 to 50%.

2. Increased set capacity: Shorter cleaning time means units are on the line longer. They stay hotter — get back into production faster. The entire grate and fire area stay clear of clinkers longer. This results in better fuel combustion and increased gas-make.

3. Longer lining life: A service life usually 3, 5 or more times that of ordinary linings. CARBOFRAX brick have high resistance to flame erosion spalling, cracking and mechanical abrasion.

4. Lower operating costs: Repeated repairs and replacements are eliminated. Shorter cleaning periods mean further savings.

The characteristics of CARBOFRAX refractories which have made the foregoing results possible also are used advantageously in producing blue gas and oil gas. These refractories are likewise employed for new gas making and reforming processes.



Boilers, too, Need Super Refractories

Shown here is a typical spreader stoker fired boiler with power operated dump grates. CARBOFRAX silicon carbide brick are used in front, side and bridge walls. Above the CARBOFRAX brick in the side walls, MULLFRAX electric furnace mullite brick are used. The unique properties of these two super refractories effectively minimize maintenance costs, eliminate frequent boiler shut downs, increase steam production and improve combustion conditions.

In the fuel bed zone CARBOFRAX brick help maintain full grate area, by offering little or no footing for clinker accumulations. Whatever clinker build up there is can be easily removed with a slice bar without impairing the face of these hard dense brick. They also resist cut-backs due to their high resistance to flame erosion and mechanical abrasion.

CARBOFRAX piers and arches in the front wall combat the very high temperatures developed here. They withstand erosive action of coal being kicked into the furnace, resist slag penetration, and minimize spalling and cracking to prolong service life.

MULLFRAX brick are installed in the upper walls because of their unique resistance to fluid ash. Their chemical inertness effectively retards erosion. They remain hard at high temperatures, thereby resisting clinker formations and mechanical wear.

This combination of CARBOFRAX and MULLFRAX brick is being used successfully in many types of stoker-fired boiler furnaces.

Super Refractory Ideal for Kiln Furniture

This picture of a vitrified hotel china kiln car superstructure was taken after 80 trips — with no rebuilding. Notice the straight, level CARBOFRAX silicon carbide setter tile. Note, too, the excellent condition of the CARBOFRAX I-beam posts despite the heavy loads carried. Also of interest is the fill obtained with this design of setting.

CARBOFRAX setters with their high hot strength minimize warpage. They stay clean — there is no boiling or blistering. Their unique thermal shock resistance minimizes cracking.

High density and refractoriness of the CARBOFRAX I-beam posts prevent "squatting." "Cornering" also is eliminated. Post life is extended to cut replacement cost and frequency of rebuilds. With a relatively thin web and smaller pads these posts make ware placing easier and faster — increase car pay-load.

Put to work as kiln furniture for various operations, CARBOFRAX setters and posts result in definite economies per piece or per dozen of ware fired.

To obtain facts and figures on installations in specific fields merely select from this list of bulletins. Copies will be sent you at once. No obligation, of course.

Super Refractories by CARBORUNDUM (general catalog)
Super Refractories for the Ceramic Industry
Super Refractories for the Process Industry
Super Refractories for Boiler Furnaces
Super Refractories for Heat Treatment Furnaces
Super Refractories for Gas Generators
The Frax Line of Cements
CARBOFRAX Refractory Skid Rails
Porous Media for Filtration & Diffusion

Dept No. C-70

THE CARBORUNDUM COMPANY
Refractories Division
PERTH AMBOY, NEW JERSEY

"The Proof . . . . . is the eating"

•

The Proof . . of the ALLOY is the *HEATING*

Admitting that provender proverb, "The way to a man's heart is through his stomach", fits gastronomically, it may be said with equal certainty that metallurgically the way to that coveted listing of "First Source of Supply" lies through Production and Cost RECORDS.

No product has yet been made but that some fellow can't scheme a way to make it *cheaper* and sell it for *less*. There are even people who sincerely believe that G.A. is too finicky about quality and controls, that they can leave out all those "fancy details" and just sell "castings".

On hand to keep those boys eating regularly are many companies who leave their High Temperature Tooling up to "casting buyers" who think in terms of first cost, of cents per pound of "castings" purchased. They even tell us, "G.A. spends too much on research; all we need is a convenient foundry."

Many "price buyers" are beginning to keep heat-hour RECORDS. Many of these buyers are starting to *reach* for value, rather than *stoop* to price.

The *proof of your alloy is in the Heating*, how it stands up under and over fire, in terms of *Useful Service Life, of Production Delivered.*

If "That which is truly *functional* is truly *beautiful*", then certainly the RECORD of Service Rendered by General Alloys engineered High Temperature Tooling delights the efficient operator, long after the "pain" of patronizing a high bidder is past. *(G.A. is not always the highest bidder.)* Among our riches we count those competitors who strive to do a good job, who will spend money to improve their product, and, of necessity, get it back with a profit.

Out to beat PRODUCTION RECORDS—REDUCE COSTS? We solicit your inquiries.

GENERAL ALLOYS COMPANY

BOSTON, MASS.

"Oldest and Largest Exclusive Manufacturers of Heat and Corrosion-Resistant Alloys"

OFFICES OR REPRESENTATIVES IN PRINCIPAL CITIES

No furnace is better than its Alloy Parts

GA X-ITE GA CHROMAX GA X-ITE GA CHROMAX

THE FOOTSTEPS OF GENERAL ALLOYS MARK THE PATH OF AN INDUSTRY

Check the Ductility
OF
Sheet Metal
WITH THIS
FAST
SIMPLE
TESTER

Pressure is applied easily, automatically — up to 30,000 pounds, with the entire test carried to completion with the operation of only one control knob.

Highly sensitive, this sheet metal tester permits fine readings. Test is made in plain view of the operator at all times. Operating mechanisms are completely and attractively enclosed in casing, as illustrated.

Let Us Send Descriptive Literature

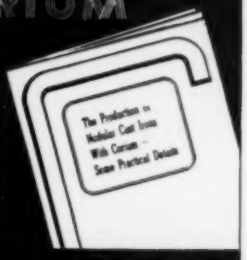
DETROIT TESTING MACHINE CO.
9390 Grinnell Avenue • Detroit 13, Michigan

News . . . about
"The Production of
NODULAR CAST IRONS"
with CERIUM

New booklet describes in detail actual foundry methods as practiced by members of the British Cast Iron Research Association.

For the first time, available in the United States.

Sent upon request



CERIUM METALS Corporation
Pioneer and Largest Producer Cerium and Cerium Alloys
153 WAVERLY PLACE • NEW YORK 14, N. Y.

Stress Relief

(Starts on page 80)

Stress Magnitudes

It is obvious that effective stress relief requires some actual knowledge of the amount of stresses remaining in an overstressed metal after a given time at a certain temperature. In the technique of stress relieving by heat there are three variables for each commercial alloy, namely, stress, time and temperature. Aside from the quantitative data contained in the book "Science of Petroleum" cited above, there are three important recent documents available: "The Effect of Time and Temperature on the Relief of Residual Stresses in Low Alloy Steels", by J. K. McDowell and Paul C. Cunnick, *Welding Research Supplement*, October 1944, and "Stress Relief of Weldments", by J. R. Stitt, Bulletins No. 121 and 123 of Ohio State University's Engineering Experiment Station, November 1944 and September 1945.

A fourth document is worthy of abstract, since it was printed 13 years ago in a publication little known to metallurgists. It is entitled "Residual Stress", and is by William C. Stewart of the U. S. Naval Engineering Experiment Station, published in *Journal* of the American Society of Naval Engineers, V. 49, August 1937, p. 307. Such an abstract follows:

The questions arise: "Is the customary stress-relieving temperature unnecessarily high?" and "What proportion of the stress is relieved at this temperature?"

These experiments were made: Test pieces (½ in. diameter, 4 in. gage length) were machined with long threaded shoulders. A heavy yoke — really a slotted slab — of the same material was arranged so the test piece could be tightened up until it stretched to its yield point (as determined by an attached extensometer). The extensometer was removed, the assembly heated for a given time and temperature, cooled, the extensometer reattached, the nuts loosened, and the contraction measured. (A keyway prevented any torsion.) Stress relief was computed from the difference in extensometer readings before and after.

Metals tested were a plain carbon boiler steel KM (0.27% C,

(Continued on page 116)

WHY GUESS THE TEMPERATURE
. . . when you can see it!

THE NEW
PYRO RADIATION PYROMETER

Tells spot temperatures instantly—in heat-treating furnaces, kilns, forging and fire boxes. No thermocouples, lead wires or accessories needed! Temperature is indicated on direct-reading dial at a press of the button. Any operator can use it. In two double-ranges for all plant and laboratory needs. Write for FREE Catalog No. 100.

Just sight it . . . and press the button!

8 Instruments in One

The Improved PYRO Surface Pyrometer handles—

all surface temperature measuring jobs. Has 8 types of thermocouples; all interchangeable in seconds with no recalibration or adjustment. Automatic cold end compensator. Shock, moisture and dust proof. Accurate, big 4¾" indicator. Available in 5 temperature ranges.

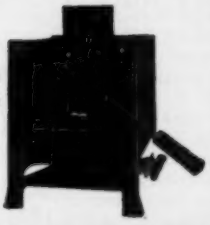
Ask for FREE Catalog No. 165

The Pyrometer Instrument Company
New Plant and Laboratory **BERGENFIELD 8, NEW JERSEY**
Manufacturers of Pyro Optical, Radiation, Immersion and Surface Pyrometers for over 25 years

"BUZZER" HIGH SPEED *Gas* FURNACES

2400 F.
attained quickly with "BUZZER" Full Muffle Furnaces

Designed primarily for heat treating high carbon and alloy steels



NO BLOWER or POWER NECESSARY
. . . Just connect to gas supply

"BUZZER" Atmospheric Pot Hardening Furnaces assure even heat up to 1650° F.

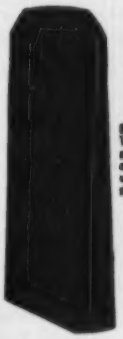
Used for Salt, Cyanide and Lead Hardening. Also adapted for Melting Aluminum.

Send for the complete "BUZZER" catalog today.

CHARLES A. HONES, INC.
123 So. Grand Ave. Baldwin, L. I., N. Y.

EVANSTEEL
adds extra STRENGTH AND WEAR LIFE TO *Parts and Sections*

Front Wheel Fork with high tensional strength for use on tractors. Over 40,000 made and used to date without a single failure.



EVANSTEEL Heat-Treated Hammers have proved far superior to any other material used for pulverizing purposes.

EVANSTEEL Dipper Teeth last longer regardless of material being dug.

EVANSTEEL Wire Rope Sockets have been made for forty years, without one recorded service failure.

You're looking at typical examples of modern engineering practice—parts made of EVANSTEEL because the job demanded maximum resistance to shock, abrasion, and breakage.

EVANSTEEL is a chrome-nickel-molybdenum alloy with a tensile strength after annealing that averages up to 60% greater than ordinary carbon steel.

Include EVANSTEEL in your parts design—and get increased service life with greatly enhanced strength which permits use of smaller and lighter sections without lowering the safety factor. Material costs are substantially lowered.

● We invite You to visit our BOOTH No. 2003 at the Chicago METAL SHOW October 23-27

Write for EVANSTEEL *Bulletin*

CHICAGO STEEL FOUNDRY CO.
Kedzie Avenue and 37th Street • Chicago 32, Illinois
Makers of Alloy Steel for Over 40 Years

PROPER DESIGN– still the most important ingredient

Despite the great advances in the use of alloy steels, the shape and proportions of a part are still of more vital significance than its material.

In an overall view, we should rate Design (1), the choice of the proper Steel (2), and its Treatment (3), in that order of importance. All are, of course, matters of great concern, but if the design is wrong then the proper choice of steel and its successful treatment serve no useful purpose.

What is the metallurgical significance of poor design? It promotes unhealthy stress concentrations and troublesome variations in the proportions of adjacent parts.

To stress the relationship of good design to metallurgical and economic factors, we have prepared a book helpful to designers, showing by sketches a great many factors in good and poor design which influence the behavior of a part in service.

Climax Molybdenum Company

500 Fifth Avenue
New York City

Please send your
FREE BOOKLET
3 KEYS TO SATISFACTION

Name.....
Position.....
Company.....
Address.....

MP-7

Stress Relief

(Starts on page 80)

0.43% Mn, with tensile strength of 63,600 psi. and proof stress of 27,300 psi.); a manganese boiler steel KL (0.21% C, 1.44% Mn, 0.11% Ni, with tensile strength of 70,000 psi. and proof stress of 34,900); carbon-molybdenum plate (0.19% C, 0.78% Mn, 0.18% Si, 0.04% Cr, 0.02% Ni, 0.48% Mo, with tensile strength of 79,700 psi. and proof stress of 40,000 psi.); all weld metal; and hot rolled monel metal (0.08% C, 0.45% Mn, 66.4% Ni, 27.8% Cu, 2.05% Fe, 3.12% Al). Stresses existing in the three boiler steels after various heating programs are shown in Tables I to III.

The findings seem to confirm the practical usage of 1100 to 1200° F. as the proper stress-relieving temperature. It appears that relaxation up to 800° F. is rather modest even after 16 hr., but above that temperature stresses are relieved quite rapidly as temperature rises. A long heating at 900° F., which cuts the highest internal stresses in third, is an important fact to bear in mind when planning the annealing of carbon steel castings which would be inclined to sag severely at higher temperatures.

Increased stress relief with time at all temperatures (except the lowest) indicates that "creep" is a factor in stress relief. The hypothesis that weldments, even if not heat treated, will relax by creep at room temperature finds little justification in the figures for manganese steel heated at 400° F. Obviously the *temperature* is of more importance in stress relief than time.

All Weld Metal—Test pieces were made of all weld metal from Grade EA mild steel electrodes, Class 2 (composition of deposit: 0.09% C, 0.55% Mn, tensile strength 67,500 psi.). Deposits were made under conditions of current and speed that the temperature did not exceed respectively 250 ("cold"), 320 ("medium"), and 400° F. ("hot"). Relaxation curves were quite similar in shape to those of the rolled steel. For example, ½-in. round samples of "cold" weld metal prestressed to 53,000 psi. retained 23,000 psi. after 1 hr. at 900° F. and 22,000 psi. after 4 hr., quite similar to results for manganese steel. On the other hand, specimens of "hot"

(Continued on page 118)

Lower Your Tube Replacement Costs with

GORDON'S "SERV-RITE" TYPE R Thermocouple Protecting Tube

For Cyanide and Salt Baths

GORDON SERVICE

Gordon Type R tubes, made and specially treated for use with thermocouples in cyanide and salt baths, not only give greater protection by preventing detrimental gas infiltration and penetration, but also have unusually long life in service. Join the many satisfied users and lower your tube replacement costs.

This is only one item in Gordon's complete line of protecting tubes for practically every application. Over a million of them have been put in service in the past few years. No matter what your requirements in protecting tubes are, both in regular and special sizes, consult Gordon first.

★ *Write today for bulletin and information*

CLAUD S. GORDON CO.

Specialists for 36 years in the Heat Treating and Temperature Control Field

Dept. 15 • 3000 South Wallace St., Chicago 16, Ill.
Dept. 15 • 2035 Hamilton Ave., Cleveland 14, Ohio

THE METALS YOU USE

● ***Here are Authoritative Facts About Their Properties and Applications. Top Experts Talk Frankly and for Your Benefit.***

One or More of These ⊖ Books Should Be in Your Metallurgical Library

Stainless Steels

By Carl A. Zapffe, *Consulting Metallurgist*

This book is written to provide both to present users and to potential users of stainless steel a relatively primary and easy-reading account of the field—an account which may err occasionally from exactitude of detail in its effort to convey important generalizations. The reader to whom the text is addressed is supposed to have only a smattering of metallurgy but a real interest in educating himself in this field regardless of his background. With no background whatsoever, he can still read with some gain Chapter I on history, Chapters IV, V, and VI on physical and mechanical properties, and possibly Chapter VII on general instructions for fabricating. In Chapters II and III, the more technically trained reader can go further to gain fundamental chemical and metallurgical understanding of these steels, which will fit him for a broad understanding of the whole field.

"... this book is a 'must' for the thousands of men working with stainless steels"
—*A. H. d'Arcambal, V.P., Pratt & Whitney.*

"I find that 'Stainless Steels' fills a long-wanted need in this particular field"—*L. H. Johnson, Chief Engr., Struthers-Wells Corp.*

"Zapffe has a style of his own, which makes all of his publications valuable additions to any library"—*W. B. Coleman, Pres., W. B. Coleman Co.*

TABLE OF CONTENTS

Chapter I (Historical background of the Stainless steels): Early Laboratory studies; Discovery; Development. Chapter II: The phenomenon of Passivity; Seven generalizations of corrosion resistance; specific applications to corrosive media. Chapter III: Principles of constitution; effects of Carbon; effects of Chromium; effect of Nickel; effect of Nickel on Iron-Chromium alloys. Chapter IV: Class I—Martensitic; physical and mechanical properties; selecting a steel for a particular service. Chapter V: Class II—Ferritic; physical and mechanical properties; selecting a steel for a particular service. Chapter VI: Class III—Austenitic; physical and mechanical properties; some effects of heat treatment; selecting a steel for a particular service. Chapter VII: Production, fabrication and finishing.

6 x 9.....illus.....red cloth.....$5.00

Sleeve Bearing Metals

A Series of Educational Lectures

TABLE OF CONTENTS

"Introduction" by H. W. Gillett, Battelle Memorial Institute; "Fundamental Considerations Concerning the Behavior of Bearings" by R. W. Dayton, Battelle Memorial Institute; "Some General Comments on Bearings" by Carl E. Swartz, Applied Physics Laboratory, Johns Hopkins University; "British Thought and Practice—How They Differ from American" by W. H. Tait, Glacier Metal Co., Ltd.; "Newer Bearing Materials" by I. C. Sleight, Specifications Engineer, Menasco Manufacturing Co., and L. W. Sink, Bearing Engineer, P. R. Mallory & Co., Inc.; "Aluminum Alloy Bearings—Metallurgy, Design and Service Characteristics" by H. Y. Hunsicker, Assistant Chief, Cleveland Research Division, Aluminum Company of America; "Porous Metal Bearings" by A. J. Langhammer, Amplex Div., Chrysler Corp.; "Moraine Durex-100 Engine Bearings" by J. A. Lignian, Bearing Engineer, Moraine Products Div., General Motors Corp.; "Cast Bronze Bushings" by Leighton M. Long, Consulting Engineer; "Mechanical Features of Steel-backed Bearings" by E. Crankshaw, Assistant Chief Engineer in Charge of Bearing Design and Application, Cleveland Graphite Bronze Co.; "Lubrication" by E. Crankshaw and J. Menrath, Design Specialist, Cleveland Graphite Bronze Co.; "Bronze-backed Bearings" by B. J. Esarey, Chief Engineer, National Bearing Division, American Brake Shoe Co.; "Electroplated Bearings" by Ralph A. Schaefer, Director of Research, Cleveland Graphite Bronze Co.; "Preparing Cast Iron Surfaces for Bonding" by J. H. Shoemaker, President, Kolene Corp.; "The Selection of Bearing Materials" by Arthur F. Underwood, Research Laboratories Division, General Motors Corp.; "Aircraft Engine Bearings" by J. Paloulich, Project Engineer, and R. W. Blair, Assistant Project Engineer, Wright Aeronautical Corp.; "Selection of Bearing Materials in the Electrical Industry" by D. F. Wilcock, Thompson Laboratory, General Electric Co.; "Railroad Journal Bearings" by E. S. Pearce, President, Railway Service and Supply Corp.

250 pages.....6 x 9.....83 illus.....red cloth.....$5.00

Physical Metallurgy of Aluminum Alloys

A Series of Educational Lectures

TABLE OF CONTENTS

"Equilibrium Diagrams of Aluminum Alloys", by W. L. Fink, Chief, Physical Metallurgy Division, Aluminum Research Laboratories; "Metallography of Aluminum Alloys", by F. Keller, Chief, Metallography Division, Aluminum Research Laboratories; "Commercial Aluminum Casting Alloys", by W. E. Sicha, Assistant Chief, Cleveland Research Division, Aluminum Research Laboratories; "Commercial Wrought Aluminum Alloys", by J. A. Nock, Jr., Assistant Chief, Physical Metallurgy Division, Aluminum Research Laboratories; "Thermal Treatment of Aluminum Alloys", by E. H. Dix, Jr., Assistant Director of Research, Aluminum Company of America.

250 pages.....6 x 9.....165 illus.....red cloth.....$5.00

Magnesium

A Symposium by 5 Authors—L. M. Pidgeon, *professor and head of department of metallurgy, University of Toronto, Toronto;* John C. Mathes, *development engineer, Dow Chemical Co., Midland, Mich.;* Norman E. Woldman, *chief metallurgical engineer, Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.;* J. V. Winkler, *metallurgist, Dow Chemical Co., Los Angeles; and* W. S. Loose, *metallurgist, Dow Chemical Co., Midland*

Based on five educational lectures, the book discusses magnesium structural design as to weight-saving possibilities, allowable working stresses, and comparisons with other structural metals in columns, beams, tubes and fabricated structures.

Magnesium casting is dealt with at length. Alloy additions, types of castings, foundry practices, heat treatment, metallography, machinability, welding, impregnation, surface finishes and properties are all considered.

Wrought alloys are discussed from the standpoint of composition, fabrication methods, drawing, press methods and controls, rubber forming, drop hammer methods, and such joining methods as riveting and arc, gas and resistance welding.

266 pages...6 x 9...118 illus....red cloth...$3.50

The American Society for Metals
7301 Euclid Ave., Cleveland 3, Ohio

Please send me:

☐ Stainless Steels $5.00

☐ Sleeve Bearing Metals 5.00

☐ Physical Metallurgy of Aluminum Alloys 5.00

☐ Magnesium 3.50

Name ..... Title .....

Firm ..... Street Address .....

City ..... Zone ..... State .....

Check enclosed ☐ Bill me ☐ Bill my company ☐

Stress Relief

(Starts on page 80)

weld metal retained 15,000 psi. after 1 hr. and 14,000 after 4 hr. at 900° F. This favorable effect of depositing weld metal in a "hot" joint was evident in all tests at the lower stress-relieving temperature, but vanished after relief at 1200° F. or higher.

Monel Metal — All samples were heated 1 hr. after prestressing to 70,000 psi. Remaining stresses are:

600° F.	66,000 psi.
800	51,500
1000	37,000
1100	22,000
1200	6,000; 8,000 (two tests)
1300	7,000
1400	5,000

These results are for hot rolled metal. Cold drawn material is frequently stress relieved at 800° F.; this permits bar stock to remain true when machined, and does not introduce any uncertainties into the endurance limit. A 1200° anneal would ruin the mechanical properties of cold worked material.

Table I — Remaining Stress in Carbon Steel Boiler Plate Prestressed to Yield (25,000 Psi.)

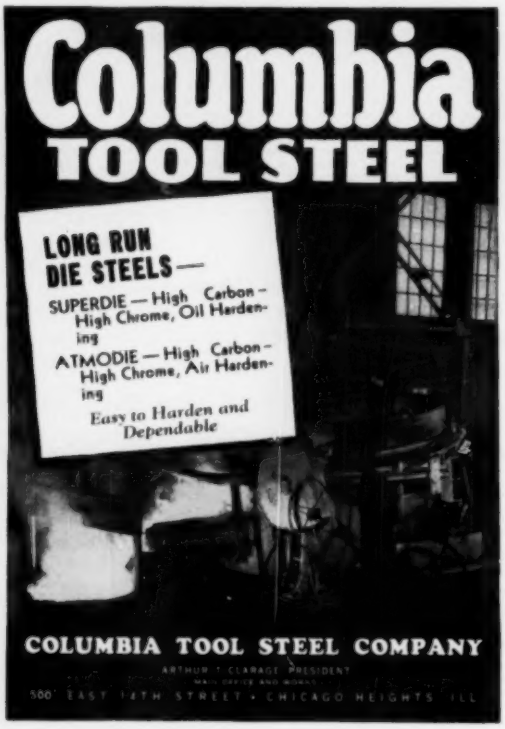
Time	400° F.	800° F.	900° F.	1000° F.	1100° F.	1200° F.	1300° F.	1400° F.
½ hr.	20,600	18,400	16,900	13,600	10,000	7,000	4,500	3,100
1	17,600	14,700	10,900	6,400	5,400	4,800	4,200	2,700
4	15,000	13,100	8,100	5,000	4,800	4,000	2,500	2,000
8	13,900	11,300	7,800	5,600	4,500	3,600	2,500	2,000
16		11,500	8,000	6,000	4,000	2,700	1,800	nil

Table II — Remaining Stress in Manganese Steel Boiler Plate Prestressed to Yield (40,000 Psi.)

Time	400° F.	800° F.	900° F.	1000° F.	1100° F.	1200° F.	1300° F.	1400° F.
½ hr.	34,000	32,500	24,000	20,000	15,000	10,500	6,500	3,800
1	32,000	28,500	22,000	12,000	9,500	7,500	5,300	1,500
4	32,000	26,500	20,000	9,500	8,000	5,300	2,500	nil
8	32,000	25,500	18,000	7,500	6,000	3,500	2,000	nil
16		24,000	15,000	9,000	5,000	3,000	1,000	nil

Table III — Remaining Stress in Carbon-Molybdenum Steel Plate Prestressed to Yield (43,500 Psi.)

Time	400° F.	800° F.	900° F.	1000° F.	1200° F.	1300° F.	1400° F.
1 hr.	—	26,200	23,500	19,500	7,500	8,000	none
4	36,000	27,000	23,500	16,200	—	—	—
8	—	27,700	—	—	—	—	—

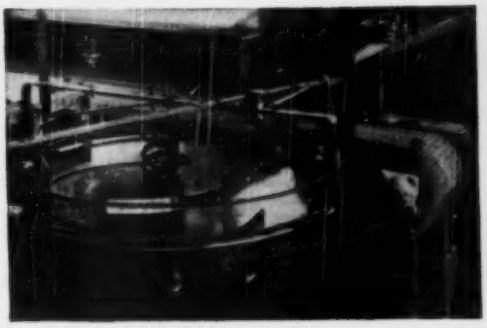

Columbia
TOOL STEEL
LONG RUN
DIE STEELS —
SUPERDIE — High Carbon – High Chrome, Oil Hardening
ATMODIE — High Carbon – High Chrome, Air Hardening
Easy to Harden and Dependable
COLUMBIA TOOL STEEL COMPANY
ARTHUR T. CLARAGE PRESIDENT
500 EAST 14TH STREET • CHICAGO HEIGHTS ILL

LENAPE
FORGED AND PIERCED RINGS
Save Hours of Machining Time
Designers and fabricators are taking advantage of the inherent economy of Lenape pierced rings of the type illustrated —the OD and ID are press formed to rough dimensions in one operation, thus saving metal and hours of machine time compared to producing from bar stock.
Use Lenape heavy rings at less overall cost!
Lenape forged and pierced rings in carbon, alloy and stainless steels are produced in a wide range of sizes from 6" OD x 3½" ID to 17" OD x 14" ID rough machined or finished to specification.
Rings of this type are frequently used as auxiliary tank fittings, heavy machinery parts, as rollers, bearing sleeves, and stuffing boxes.
Lenape forged and pierced rings are covered in detail on page 46 of Lenape Catalog 9-49. A copy will be sent upon request. Your specific inquiry will be given our immediate attention.
LENAPE
HYDRAULIC PRESSING AND FORGING CO.
LENAPE HYDRAULIC PRESSING & FORGING CO.
DEPT. 109 WEST CHESTER, PA.
RED MAN PRODUCTS

. . . METAL Conveyor Belts

ASHWORTH

Engineered and built by an organization of moderate size with the will and ability to analyze your problems and "Keep Your Product on the move."



WRITE FOR ILLUSTRATED CATALOG 47P

ASHWORTH BROS., INC.
METAL PRODUCTS DIV. • WORCESTER, MASS.

Sales Engineers located in Buffalo • Chicago • Cleveland • Detroit Los Angeles • New York • Pittsburgh • Seattle
Canadian Rep., PECKOVER'S LTD. Toronto Montreal Halifax Winnipeg Vancouver

HARPER WIRE ANNEALER . . .
ANNEALS 298,636 MILES OF WIRE IN 1 YEAR

The above 30-tube electric atmosphere furnace has been in continuous operation at a leading wire plant for the past two years without a trace of trouble.

Annealing of stainless steel wire in sizes of .020 to .0014" is done at the rate of 100 fpm at 2000°-2300° F.

Wire of exceptionally uniform quality is obtained as a result of closely maintained uniform temperatures possible in this furnace.

Harper Wire Annealing Furnaces are available in various sizes and what Harper has done for one mill can be duplicated for you. Write for data.

HARPER ELECTRIC FURNACE CORPORATION
1450 BUFFALO AVENUE • NIAGARA FALLS • NEW YORK
Representatives in Principal Cities

For ECONOMY'S SAKE Install THURNER CARBO-CLEANER

Install a Thurner CARBO-CLEANER and you'll end at once the pitting and waste of heating time caused by insulating dirt... the cost in man-hours spent in the removal of undesirable materials from used carburizer!

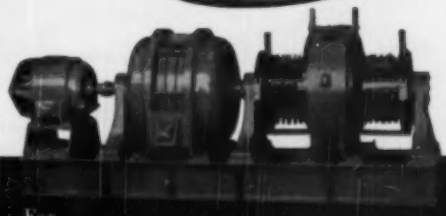
The Thurner CARBO-CLEANER is a low-priced, automatic carburizer cleaning machine that is designed to cut manufacturing and heat treating costs without sacrifice of workmanship!

CARBO-CLEANER is easy to operate . . . the used carburizer is dumped into the machine, it is fed automatically into a rotary drum and passed over 23½ feet of screen. All undesirable material is completely removed and the reclaimed carburizer returned *clean and aerated, ready to use again!*

WRITE FOR COMPLETE DETAILS!

THURNER ENGINEERING CO.
801 WEST NATIONAL AVENUE
MILWAUKEE 4, WISCONSIN

Motor Generators by COLUMBIA



For
Electroplating Anodizing
Electrocleaning Electropolishing

There's a Columbia M-G Set available for your needs, whether you have a small plating bath or a large continuous strip plating line. Capacities up to 20,000 Amperes; 6 Volts and up. Dependable, performance proved, for many years. Your inquiries solicited.

Write today for Catalog MP-700

COLUMBIA ELECTRIC MFG. CO.
4531 HAMILTON AVENUE CLEVELAND 14, OHIO

METAL PROGRESS

A. P. FORD, *Advertising Manager*; GEORGE H. LOUGHNER, *Production Manager*
7301 Euclid Ave., Cleveland 3—UTah 1-0200

ROBERT S. MULLER, *Eastern Manager*
55 W. 42nd St., New York 18—CHickering 4-2713

DON HARWAY, *Pacific Coast, 1709 West 8th St., Los Angeles 14—DUnkirk 2-8576*

PUBLISHED BY AMERICAN SOCIETY FOR METALS, 7301 EUCLID AVE., CLEVELAND 3, OHIO—W. H. EISENMAN, SECRETARY

• Index to Advertisers •

Acheson Colloids Corp.	105
Air Reduction Sales Co.	22
Ajax Electrothermic Corp.	101
Allied Research Products, Inc.	16D
Alloy Casting Co.	16A
Aluminum Co. of America	17
American Brass Co.	16B-16C
American Chemical Paint Co.	109
American Gas Furnace Co.	80C
American Society for Metals	110, 117
Ashworth Brothers, Inc.	119
Austenal Laboratories, Inc.	15
Barrett Div., Allied Chemical & Dye Corp.	111
Bausch & Lomb Optical Co.	80D
Bell & Gossett Co.	4
Bethlehem Steel Co.	23
Buehler, Ltd.	16
Burrell Corp.	108
Carborundum Co.	42, 112A-112B
Carlson, Inc., G. O.	94
Carpenter Steel Co.	40
Cerium Metals Corp.	114
Chicago Steel Foundry Co.	115
Cities Service Oil Co.	99
Clark Instrument, Inc.	112
Climax Molybdenum Co.	116
Columbia Electric Mfg. Co.	119
Columbia Tool Steel Co.	118
Copperweld Steel Co.	Back Cover
Crucible Steel Co. of America	35
Delaware Tool Steel Corp.	30
Detroit Testing Machine Co.	114
Dow Chemical Co.	7
Driver-Harris Co.	29
Eastman Kodak Co.	97
Electric Furnace Co.	Inside Back Cover
Electro Alloys Co.	44
Electro Metallurgical Div., Union Carbide & Carbon Corp.	20
Ferner Co., R. Y.	32A
General Alloys Co.	113
General Cerium Co.	112
Gordon Co., Claud S.	28, 116
Gray Iron Founders' Society, Inc.	12
Great Lakes Steel Corp.	37
Gulf Oil Corp.	19
Harper Electric Furnace Corp.	119
Heat Duty Electric Co.	6
Holcroft & Co.	98
Hones, Inc., Charles A.	115
Hoskins Mfg. Co.	41
Houghton & Co., E. F.	31
Induction Heating Corp.	46
Inland Steel Co.	50
International Nickel Co., Inc.	26, 80A
Johns-Manville	104
Jones & Laughlin Steel Corp.	39
Kemp Mfg. Co., C. M.	102
Kux Machine Co.	34
Lakeside Steel Improvement Co.	120
LaSalle Steel Co.	43
Leeds & Northrup Co.	3
Lenape Hydraulic Pressing & Forging Co.	118
Lepel High Frequency Labs.	103
Lindberg Engineering Co.	9
Linde Air Products Co., Unit of Union Carbide & Carbon Corp.	14
Maurath, Inc.	32B
Michigan Steel Casting Co.	36
Minneapolis-Honeywell Regulator Co. (Industrial Division)	107
National Carbon Div., Union Carbide & Carbon Corp.	33
National Machinery Co.	10
Norton Co.	48
Ohio Crankshaft Co.	1
Ohio Steel Foundry Co.	103
Olsen Testing Machine Co.	38
Pangborn Corp.	109
Park Chemical Co.	100
Pressed Steel Co.	2
Pyrometer Instrument Co.	115
Republic Steel Corp.	18
Revere Copper & Brass, Inc.	91
Riverside Metal Co.	11
Rockwell Co., W. S.	30
Rolock, Inc.	25
St. Joseph Lead Co.	24
Sharon Steel Corp.	45
Sperry Products, Inc.	32
Standard Alloy Co., Inc.	92
Stuart Oil Co., D. A.	108
Surface Combustion Corp.	Inside Front Cover
Thurner Engineering Co.	119
Timken Roller Bearing Co.	13
Titanium Alloy Mfg. Co.	95
Union Carbide & Carbon Corp.	14, 20, 33
Vanadium Corp. of America	47
Westinghouse Electric Corp.	21
Wheelco Instruments Co.	93
Wheelock, Lovejoy & Co., Inc.	106
Wilson Mechanical Instrument Co.	96
Wisconsin Steel Co.	5
Youngstown Sheet & Tube Co.	8

Our Services: Carbonitriding, Electronic Induction Hardening, Flame Hardening, Heat Treating, Bar Stock Treating and Straightening (mill lengths and sizes), Annealing, Stress Relieving, Normalizing, Pack, Gas, or Liquid Carburizing, Nitriding, Speed Nitriding, Aerocasing, Chapmanizing, Cyaniding, Sand Blasting, Tensile and Bend Tests.

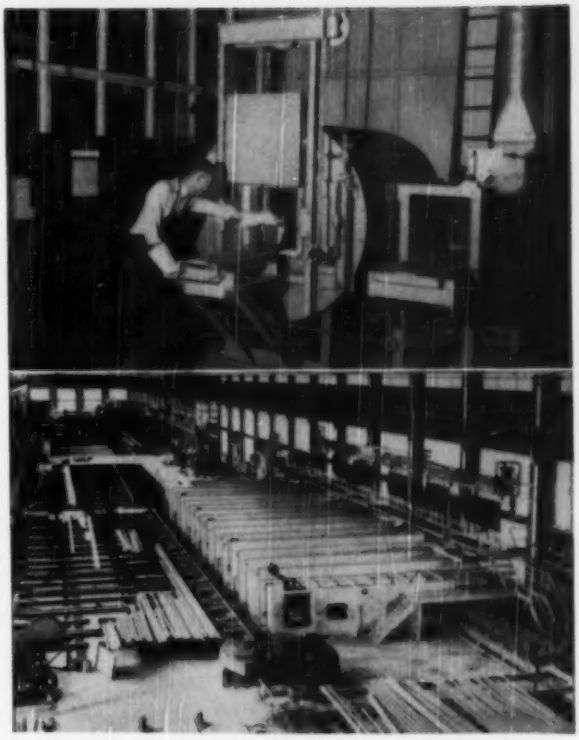
Approved Steel Treating Equipment by U.S. Air Force—Serial No. DE-S-24-1 through 30.

THE *Lakeside Steel Improvement Co.*

5418 LAKESIDE AVE., CLEVELAND 14, OHIO HENDERSON 1-9100

TOWER PRESS
CLEVELAND

Small EF Forced Circulation Furnace for Brazing, Solution Treating and Aging Aluminum Products.



for
HOMOGENIZING
SOLUTION TREATING
AGING
BILLET HEATING
BRAZING
FINISH ANNEALING
OR ANY OTHER PROCESS

There's an

EF furnace to handle any product or production

Completely Automatic EF Furnace Heats and Quenches Aluminum Shapes up to 90 Feet Long.

● Our wide experience in the processing of aluminum, magnesium and other non-ferrous and ferrous products can save you time and money. We build continuous and batch type furnaces,—gas fired, oil fired or electric . . . whichever is best for your particular requirement — furnished complete with all necessary charging, discharging, quenching, special atmosphere and special handling facilities. For long, efficient, trouble-free service, let EF engineers work with you on your next furnace problem.

Gas-Fired, Oil-Fired* EF *and Electric Furnaces
for any Process, Product or Production

THE ELECTRIC FURNACE CO.

WILSON ST. at PENNA. R. R. *Salem - Ohio*

ARISTOLOY STEELS

HIT THE MARK

ARISTOLOY STEELS

- STANDARD STRUCTURAL ALLOY
- BEARING QUALITY • ALLOY TOOL
- SPECIALTY • NITRALLOY
- CARBON TOOL • STAINLESS
- MAGNAFLUX— AIRCRAFT QUALITY

COPPERWELD STEEL COMPANY, WARREN, OHIO

117 Liberty Street
New York, New York

176 W. Adams Street
Chicago, Illinois

P. O. Box 1633
Tulsa, Oklahoma

1578 Union Commerce Building
Cleveland, Ohio

7251 General Motors Building
Detroit, Michigan

403 W. Eighth Street
Los Angeles 14, California

528 Fisher Building
Detroit, Michigan

3104 Smith Tower
Seattle, Washington

Monadnock Building
San Francisco 5, Calif.